Science AMA Series: I am Jerry Dickens, science faculty member at Rice University and co-chief scientist for the drilling expedition to understand the submerged continent of Zealandia – ask me anything!

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April 17, 2023

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CORRESPONDENCE:

DATE RECEIVED:
March 17, 2017

DOI:
10.15200/winn.148966.68645

ARCHIVED:
March 16, 2017

CITATION:
Jerry_Dickens , r/Science , Science AMA Series: I am Jerry Dickens, science faculty member at Rice University and co-chief scientist for the drilling expedition to understand the submerged continent of Zealandia -- ask me anything!, *The Winnower* 4:e148966.68645 , 2017 , DOI: 10.15200/winn.148966.68645

I'll just get these out of the way...

What is Zealandia?

Why is it mostly underwater?

What does this tell us about Earth history?

Why is Zealandia interesting for climate research?

Why is Zealandia interesting for biology?

How will you figure out the basics as to how Zealandia evolved time?

And my main quezzy- What sort of analyses will be conducted on these cores? (Radiocarbon, C-O-S isotopes, geochemical, lithological, micro/macro fossils etc.. ?)

HerbziKal

Zealandia is a large region in the southwest Pacific Ocean underlain by continental crust. It includes New Zealand and New Caledonia, but also extensive regions underwater, such as the Lord Howe Rise, Challenger Plateau, etc.

Why is it mostly underwater?

In many places, the continental crust of Zealandia is extensively stretched, so it is much thinner than on other continents. Here, think about the principle of isostacy and the relative densities of continental crust, oceanic crust, and the mantle: the thinned Zealandia does not “float” as high as other continents.

What does this tell us about Earth history?

This is a great question, one partly addressed below. At the really basic level -- how can a continent become so thin during rifting that it remains mostly submerged? This is a real challenge for the community that studies plate tectonics.

Why is Zealandia interesting for climate research?

One of the great problems in current Earth Science literature is the Early Eocene, nominally 50-53 million years ago (Ma). This is because Earth surface temperatures were nominally 10-12°C greater than today, and exceptionally warm at high latitudes.

All explanations to date involve elevated atmospheric pCO2, but the extreme high latitude temperatures remain an issue, even after considering differences in albedo (little or no “white” reflective ice at the poles during the early Eocene). Quite simply, our community has not been able to replicate such temperatures using climate models. There is also the issue of why pCO2 was so high.

The most difficult early Eocene temperature records to account for are those generated from within and around New Zealand. Not only does the submerged portion of Zealandia have many early Eocene sediment sequences, but the past location and water depth of Zealandia may explain much of the data-model issues.

It is also possible that the tectonic history of Zealandia directly relates to the high pCO2. Notably, when Zealandia stopped separating from Australia (~53-50 Ma), subduction of began on the western side of the Pacific Plate. This subduction is mostly under oceanic basalt, rather than continental crust.

I should emphasize here that I when I state there are major problems in data-model comparisons for early Eocene climate, this is not a knock on either. It is simply that we cannot explain the available data with available models.

Why is Zealandia interesting for biology?

My favorite example is Araucariaceae. These coniferous trees dominated the Mesozoic landscape of Gondwana. When Zealandia began separating from Australia (and Antarctica) in the Cretaceous, presumably Araucariaceae forests continued on fragments that remained above sea level. We now have a world where these once globally dominant trees, through evolution and separation, are heavily skewed in terms of abundance toward New Caledonia and New Zealand.

How will you figure out the basics as to how Zealandia evolved time?

Great question. It’s hard to explain without looking seismic data, so please see:

http://publications.iodp.org/scientific_prospectus/371/

Hopefully, what you will see are packages of sediment that have accumulated across the Lord Howe Rise and Norfolk Ridge. The uppermost sediments are “flat-lying”, and presumably middle Eocene or younger in age; the lowere sections are “folded”, and presumably early Eocene or older in age. We think that this is the change from an extensional regime to a compressional regime.

And my main quezzy- What sort of analyses will be conducted on these cores? (Radiocarbon, C-O-S isotopes, geochemical, lithological, micro/macro fossils etc.. ?)

Well, maybe someone will measure radiocarbon in the very top sediments, but anything below a m or so should be radiocarbon dead.

Instead, as surmised, we will be very much be analyzing the sediments for their lithology, microfossils, carbon-oxygen-sulfur isotopes, and numerous other things.

The very first site will be sort “wildcat” drilling. There are numerous flat-topped features below the seafloor on the northern end of Lord Howe Rise. We are not sure what these are, as they have never been drilled. One speculation is that they are buried reefs.

It's 2017. Plate tectonics was pretty well established by the late 1960's. Why has it taken 50 years for scientists around the world to recognize Zealandia?

PapachoSneak

This is an interesting question, to which a reasonable answer comes in two parts.

1/ We did not know the bathymetry (seafloor depths) of this region very well until well after 2000. In fact, many portions are still not mapped. (As a funny aside, I was part of the 1999 cruise to define the “well-known” French-Australian boundary between New Caledonia and Lord Howe Island – which just happened to occur during the Rugby world cup finals where Australia beat its neighbor France).

2/ We did not know that all the “parts” were connected by thinned continental crust until very recently.

When the concept of Zealandia was first introduced (1995), it was thought as some sort of agglomeration of oceanic and continental fragments, as opposed to a mostly submerged “in tact” continent.

How are we able to tell that Zealandia was an old continent that was submerged rather than a younger continent that might be rising out of the ocean floor? Could you give us a rundown of the kind of things that have been found in cores for example to tell us this...or about any other evidences other than the cores that also indicate this?

Thanks so much for taking the time to visit and answer our questions. This is very interesting stuff!

OnStilts

This is an interesting question.

First, it is fun to think about islands. Places like Hawai'i, Iceland, the Azores, etc., lie above "hot spots" and are composed almost entirely of relatively young basalt. Then, there are island arcs along subduction zones, such as the Marianas, outer Antilles, Aleutians, etc., which are also composed almost entirely of relatively young basalt, albeit of a slightly different composition.

But then you have islands, such as New Zealand and New Caledonia, which are underlain by mostly continental cruse and where you can find very old rocks (>260 million years). Madagascar and Ireland are also good examples. These are fragments of continents that have been separated from other continents through tectonics, sea-level, or both.

What makes Zealandia special is that a very large area of continental crust lies submerged. This has been realized by dredge and drill samples and geophysical surveys (which indicate the density of the crust).

For example, one of the only open ocean drill sites to ever penetrate rhyolite was DSDP Site 207 on the Lord Howe Rise.

How long ago is this continent estimated to have gone underwater? Based on that, what evidence are you most hopeful to find to help answer that question?

omfghaxes

This is a really good and open question.

Clearly, portions now remain above water -- New Zealand and New Caledonia. But much of both these areas have also been underwater in the last 80 million years. One only needs to travel around the

South Island of New Zealand or New Caledonia to realize that much of the "landscape" is now uplifted "submarine" rocks.

Then there is the cool issue that places like the Lord Howe Rise (now almost entirely underwater) have features that look like they were formed by subaerial exposure in the Eocene.

So, the history of Zealandia, and particularly when it went "up and down" is very much a primary goal of upcoming drilling.

Thank you in advance for your time! On a side note, did you goas Medusa for Halloween? haha

On a serious note, I have two questions.

1. You mention drilling to obtain sedimentary cores, so it is clearly possible to extract soil from the submerged continent. I've read that Zealandia contains bountiful mineral deposits, such as iron and manganese. Do you foresee private companies extracting these minerals in the near future, or are they simply too inaccessible? I admittedly know very little about this sort of issue, so please correct me if I've made any incorrect assumptions.
2. Other than its size, what are some of the main geological differences between Zealandia and other submerged microcontinents, such as the Kerguelen Plateau?

entropydecreaser

No clue about being Medusa for Halloween, but an interesting idea for this coming fall, although my hair surely will not grow that long by then :)

1/ We will undoubtedly collect hundreds of meters of sediment, which lie on top of basement. This can bee seen in seismic lines which show the structure below the seafloor. I don't think we will be contacting any mineral deposits given the nature of things.

Some of the deep extensional basins on the Lord Howe Rise may have hydrocarbons. This is because some of them contain ~4 km of sediment. But this is well beyond the scope of our upcoming drilling.

2/ The geological differences are nicely highlighted in the paper by Mortimer and colleagues. See: http://www.geosociety.org/gsatoday/archive/27/3/article/GSATG321A.1.htm

There are sort of a natural breaks in terms of size and crustal composition, such that Zealandia fits as a continent, Kerguelen fits as a large igneous province (LIP), and areas such as Madagascar fit as microcontinents.

What is your one burning question that you want answered from this expedition?

conman526

This is tricky to answer, so I give you two.

Was the Lord Howe Rise above water during the early Eocene? This would be cool to document and would explain many things.

Was the onset of Tonga-Kermadec subduction linked to widespread plate tectonic changes in the Pacific and coincident with the onset of Cenzoic climate cooling? This would be revolutionary if correct.

As a New Zealander, I have always known that my continent was bigger than Australia and I would just

like to know when you predict we are going to use our tectonic forces to overwhelm and crush our puny western neighbor back deep down into the primeval oceanic mud flats from whence it came. Thank you!

UWarchaeologist

Well, for better or worse, Zealandia will never be bigger than Australia in the near future -- it's about 2/3 the size and tectonic forces are too slow to reshape things over at least the next 10 million years. However, you can still beat up Australia in rugby on most years if that helps :)

What is a continent and why are there (now) eight of them (e.g. why is Europe a continent but India isn't)?

Why is Zealandia a continent, but Kerguelen isn't?

Exarch_Of_Haumea

Both of these are very good questions. The term continent is somewhat arbitrary. For example why are North America and South America separate continents when connected by the Panama Isthmus? And why are Africa and Eurasia distinct when connected by the Sinai?

In really general terms, we might define continents as large areas of Earth’s surface underlain by continental crust and separated (mostly) from other such areas by oceanic crust.

I don’t think most geoscientists would consider Europe and Asia as separate continents, as they are clearly one landmass.

India is not a continent because it is now also connected fully to Asia. However, it very much used to be a continent, between about 120 and 30 million years ago.

Kerguelen is not a continent because it is mostly comprised of basalt. Instead, Kerguelen is a submerged large igneous province (LIP).

In the paper by Mortimer and colleagues, they nicely place areas of relative elevation into continents, LIPs (e.g., Kerguelen), and microcontinents (e.g., Madagascar).

Thanks for doing this AMA Jerry. My question: is there any way of telling (now or through future research) if and when Zealandia would have been a part of any of the supercontinents (such as Pangea, for example) specifically, above the surface at any time. If yes, would this explain how any species may have radiated (both modern and extinct species?) Also, how large was Zealandia, and how would this have affected climate before it was submerged? Is there any evidence, or at least any "smoking guns" that would hint at any other "lost continents" (regardless of size?) [Actually, that's four questions, not one. Sorry. Thanks again!)

GaryMitch31

These are great questions. Let's see if I can dissect.

1/ We pretty much know Zealandia began separating from the combined Australia-Antarctica portion of Gondwana in the late Cretaceous (>80 million years ago). It was almost assuredly above surface at this time.

2/ Yes, I think so, especially with trees. See above comments on Araucariaceae or google. Pretty fascinating that most of these trees, which once dominated the world, are now extant to New Zealand

and particularly New Caledonia.

3/ This is one of the main goals of the upcoming expedition. We think that Zealandia (currently ~4.9 x 10e6 km2) has been about the same size when it separated. However, there is huge debate as to when things submerged/emerged. We see many features across Lord Howe Rise that suggest widespread emergence during the early Eocene.

4/ There are sadly probably no other "lost continents". While much of the seafloor remains unmapped in detail (perhaps 90%), we know the basics through satellite measurements. If you strip the water off the globe, you will see there are no other large blocks of relative height.

I don't have enough knowledge of this subject, could you please make an eli5? Also, I'm reading it's like researchers have just recently found some sort of "continent" how is this even possible? Is this gonna become a new way of teaching the continents to primary school?

casaboza1912

Apologies, although on a funny note, I had to look up what eli5 meant!

The real basic question is “how does one define a continent?” For example, why are North America and South America generally considered separate continents when they are connected by the Isthmus of Panama?

So, we then get into the realm of definitions, where probably the best one is: “A continent is a large area of Earth’s surface underlain by continental crust mostly separated from other such areas by oceanic crust.” This nicely explains the well-known continents.

For reference, think of continental crust as the rocks on hipster kitchen counters, such as granite or schist, which have a density somewhere around 2.7 g/cm3, and oceanic crust as the dark rocks sometimes used in gardens, called basalt, which have a density somewhere around 2.9 g/cm3.

Now consider the principle of isostacy – here think of ice and cork pieces in a glass of wine (although this is a bit confusing, because with the Earth, it’s continental crust (cork) and oceanic crust (ice) somewhat floating in the mantle, and most people would not want cork or ice in their wine!). The thickest and least dense pieces float the highest. So, the continents are high because they are floored by relatively thick and less dense continental crust (often > 30 km), and oceans are low because they are floored by relatively thin and dense oceanic crust (typically < 10 km). And the water -- the ocean -- fills in the low portions.

Then, we have Zealandia, which is floored by thin continental crust, so most of it sits much higher than typical regions of the ocean but much lower than typical regions of continents!

We have known about this aspect of our Earth around New Zealand and New Caledonia for well over 20 years. However, it has only recently become clear, through seafloor mapping, that the region is one connected continental block. Hence, a mostly submerged continent -- a thin but expansive region of cork.

Hello! I graduated from Rice in 2015! I was in the chemical engineering program though, Jones college, and I don't believe we ever met. Most of the interesting science related questions I had have been asked. So I'll ask something a bit off topic - Do you work with Rice students on your work/research related to this? What is your favorite residential college at Rice? Have you ever been to Beer Bike?

Thanks! Say Hi to Willy for me :)

ashtrayheart3

Yes, graduate students and I (along with great colleagues from New Zealand, New Caledonia and Australia) have been working on aspects of Zealandia for almost 25 years (I even now like Vegemite).

I have been a judge at beer bike. Favorite college at Rice: Jones ... F-Jones ... MBYM!!

Who finances this trip and exploration?

meowoof86

The International Ocean Discovery Program.

Has a continent does it preserve the lithologic characteristics of one? Like mainly igneuos rocks being granite, was this way you discovered ?

jah-lahfui

Well, I should say outright that I certainly did not discover Zealandia!

But, yes, the way it was surmised to be a continent relates very much to the rocks and to a series of cruises over the last 20 years that have shown the characteristics though dredging, drilling, mapping and seismic profiles.

Out of curiosity, what characteristics define Zealandia as a continent? And are there any means through which the underwater portion could someday rise above sea level?

GanjaGremlin18

The primary characteristics that distinguish Zealandia as a continent are that it is large area underlain by continental crust and separated from other such regions by oceanic crust. The recent paper by Mortimer and colleagues, which is pretty easy to read for a science paper, discusses this nicely. The paper is open access at: http://www.geosociety.org/gsatoday/archive/27/3/article/GSATG321A.1.htm

I don't think significant portions, other than those already exposed, will rise above sea-level anytime soon. This is the wonderfully interesting thing about tectonics and time: the processes operate very slowly compared to human lifespans.

Nonetheless it is interesting to think about what Zealandia might look like in 10 or 20 million years. Almost assuredly the North and South Islands of New Zealand will become further separated because of the Alpine Fault. My first thought is that the continent overall will become further submerged. This is because the main compression in the region has been now compensated by the Kermadec-Tonga subduction zone; that is, at a basic level, the continent is already very thin and there are no forces to push it up, except along the South Island.

What do you think of the recent discovery of Mauritia in the Indian Ocean?

S_T_R_A_T_O_S

This is interesting to think about.

Throughout the oceans, there are several fragments of isolated continental crust, this being one of

them. The recent paper by Mortimer and colleagues (links above) notes many of these as well as large igneous provinces (LIPs). I think most in the geoscience would call the Mauritia a "microcontinent". The difference here is that Zealandia is much larger in area.

Perhaps sad but interesting, I do not think there are any other hidden continents, although maybe one or two microcontinents. This because are maps of the seafloor (enhanced hugely through satellites) have become much better; that is, there are no large masses of elevated seafloor not already known.

What made Zealandia interesting is that, while we knew this portion of the seafloor to elevated for a long time, and underlain continental crust, we did not know until recently that all was truly connected.

I teach plate tectonics in my Earth Science class. Will this require a redrawing of theplate map in the New York State Reference Table?

What plates is it converging with, diverging from?

Could you give any good resources where I could explain this to my class, many who are English Language Learners and have low reading levels?

monkeydave

This is a difficult but really important concept that somehow, we as teachers, need to convey: plates are NOT equal to continents.

From the perspective of describing plates, adding Zealandia as a continent makes no change to conventional views. Like North America or Eurasia, the continent straddles multiple plates (in this case the Pacific and Australian plate). I think Mortimer et al. did a nice job with their figures, such that students can nicely see the differences. See:

http://www.geosociety.org/gsatoday/archive/27/3/article/GSATG321A.1.htm

From the perspective of understanding plates, adding Zealandia is very important. For reasons that we hope to learn more about, this continent became very stretched during rifting and extension from Gondwana. In some ways, Zealandia becomes a great way to think with students about isostasy: where does a continent lie when you have thin continental crust? (It sits elevated from surrounding oceanic crust but mostly submerged).

What will the execution of this survey look like? Will you start with the perimeter? How far apart will dig sites be? I'm looking forward to all the new information we'll get from this over the years! Especially new species and fossils!

Evan_dood

The expedition trajectory is on line.

See: https://iodp.tamu.edu/scienceops/expeditions/tasman_frontier_subduction_climate.html

As noted above, I would not get hopes high for macrofossils. This would be an astonishingly find in drill core; however, if you are interested in microfossils, this should be a treasure trove.

Would Zealandia not be submerged if we were in an ice age? When exactly did it sink into the ocean? Could it hold a large number of fossils for us to find?Thank you in advance for responding.

KurtmeansWolf

Sea level is a difficult concept because the sea is not level due to gravitational and other effects. But yes, more of Zealandia would be exposed in an ice age.

However, even in an extreme ice age, such as that ~20,000 years ago, most would still be submerged. This because much of Zealandia is >500 m below sea level and the eustatic component of sea-level (think of as the line in the bath-tub) has probably varied within plus 130 m (melting of most terrestrial ice in the early Eocene) and minus 130 m (growing large ice sheets across Canada and Scandinavia in the Pleistocene.

On the long time frame, however, we do not know the "up and down history" of Zealandia very well -- a key concept behind upcoming drilling. Large parts may have been above sea level in the Eocene.

We will almost assuredly drill through billions of fossils, but I think this is not what you are are referring to. We are pretty sure that much of the sediment at most of our locations will be full of microfossils (the remains of coccolithophorids, foraminifera, diatoms, etc.). The chances of finding terrestrial fossils (other than pollen remains) is very, very small -- just like on most continents.

Has Zealandia ever been above sea level, with the exception of the other islands there?

Also, do you know when the continent became submerged?

pragmatic_

Well, parts of Zealandia are still above sea level!

Hopefully, the rest of your questions are addressed in above responses.