New Insights into the Origin and Distribution of Phosphate Deposits on the Chatham Rise

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Outline

• Chatham Rise geology and paleoceanography
• Deposit characteristics:
  • Nodule shape and texture
  • Geochemistry
• Conclusions
  • Are there signs of multiple phosphatisation events on the Rise?
World Class Phosphate

Phosphate known from samples on the Chatham Rise since 1952

Chatham Rock Phosphate holds an exploration license over part of the Rise, has applied for a mining license

Kenex is involved in application processing, database management, surveying and prospective/geological modelling

Mullich & Rasch 1985
Tectonic Setting

- Coherent structural high extending 1100 km east from the South Island.
- Formed through Late Cretaceous rifting from Gondwana, as a volcanic arc.
- The Chatham Peninsula persisted through the Paleocene, followed by limestone deposition in the central and east.
Cretaceous faulted basement and fault basin fill, followed by hiatus

Late Eocene cherty marl/limestone—Early Oligocene soft to firm nannofossil chalk, followed by hiatus

Mid-Miocene limestone and hardground, phosphatised to nodular gravel in Late Miocene as lag deposit on firm to hard Oligocene top surface, overlain by soft Neogene terrigenic/glaucosnatic mud.

Late Neogene phosphatisation, glauconitisation and glacial influence in the Plio-Pleistocene.

Either nodules are the same age as underlying chalk, phosphatisation younger and possibly multistage (von Rad et al 1984)

Or: Early-mid Miocene chalk phosphatised in Late Miocene (12 – 7 Ma, Cullen 1987).
Oceanographic Setting

Modern Subtropical Front on southern flank of Chatham Rise.

O2 minimum zone associated with Upper Circumpolar Deep Water

Important feature in S. Pacific paleoceanography.

Deep coring mostly on flanks and in adjacent basins (crest = condensed section).

Hayward et al 2004
Sampling efforts

Surveys in the 60s (Global Marine/JBL), 1978 (Valdivia) and 1981 (Sonne)

Methods include high-resolution seismics and shallow-penetration sampling.
Sample distribution
Paleoclimatology

Shallow OMZ needed for phosphatisation on crest?

Phosphatisation during older Austral cooling events as well? (m. Eocene, Eo/Oligo, Oligo/Mio?)
CRP 2011/2012 Surveys

- 4 surveys from Dec 2011 – April 2012
- > 200 samples using grabs, box corers and vibro coring.
- > 1100 km² of multibeam bathymetry
- > 100 km of ROV transects
CRP 2011/2012 Surveys

Irregular seabed, with (glacial) scours and pits

50 large grab samples (500 – 2000 kg / sample)

43 ROV transects for environmental studies
Seafloor Characteristics

- Soupy glauconitic sandy mud over lag layer of phosphatised hardground nodules

- Substrate is a stiff, intensely bioturbated pelagic chalk.
Sampling method

The larger the grain size, the smaller the sample...
Large samples, large efforts

Onboard sample processing, R/V Sonne 1981
Fines were thrown back.
Von Rad & Rösch 1984

Onshore sample processing, 2012
Fines were kept, if washed with freshwater
Multiple Events? Nodule Shape

- Older hardgrounds may have undergone more intensive alteration leading to smoother texture and rounder shape.
- Samples mainly from Oligocene seismic facies...

Seismic facies (Falconer et al. 1984)
Nodule Shape - Middle of Crest

Round/smooth = most intense alteration
Irregular/rough = less alteration

Rounded, smooth nodules
Most ‘mature’ deposit?
Nodule Shape - Eastern Area

- Pitted nodules, obvious bores/burrows
- Partially phosphatised and less altered hardground
- Less mature deposit?
Nodule Shape - Southern area

Irregular nodules, obvious bores/burrows.

Less mature deposit?
Nodule Shape - Northern Area

Irregular nodules, pitting, bores, and burrows.

Less mature deposit?
Intensity of Phosphatisation

116 samples with XRF geochemistry (out of > 1400)

Tendency for low (and highest?) P points to fall on the periphery

Bulk (XRF) geochemistry, > 8 mm
Geochemical Populations

Signs of 2 populations of phosphate nodule geochemistry
High Al + K = glauconite, but...
High Al + K + Na samples are almost exclusively Sonne/Valdivia samples
DD and Ti samples are from the western (northern) region, and generally in Oligocene sediment facies.

So and Va samples are from the south and east, and often in younger (Miocene) sediment facies.
Oligocene vs. Miocene Nodules

Are the Miocene samples (red points) less ‘mature’?
Will the nodules tell the story?

Phosphatisation progressed inwards from the outside.

Can detailed analysis of nodules show multiple phases of alteration? (backscatter, scanning XRF)

Samples from a wider area wanted!
Conclusions

• Chatham Rise is covered by cool-water pelagic carbonate, hardground rubble and unconsolidated sandy mud. Sediment ages and hiati tie in with onshore geology (multiple Marshall Paraconf. equivalents?)
• Hardground formation associated with influx of cool bottom water from Antarctic/Southern Ocean events. Phosphatisation associated with OMZ establishment and fluctuation (only shallow OMZ?)
• Nodule shape and texture suggests most ‘mature’ nodules on the crest compared to margins. Most evenly phosphatised samples are found on the crest compared to the margins (most erosion on crest?)
• Most geochemically immature nodules are associated with marginal and younger sediment facies (lab factor versus locality issues)
• Individual nodule analysis can reveal possible multistage phosphatisation
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