

Modelling investigations on deep sea mine tailing plume dispersion on the Chatham Rise

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Introduction

This paper describes a study that was conducted to investigate the dispersion behaviour of fine sediments in water depths of ~ 350m released during a mining tailings return process in the framework of the Chatham Rise Rock Phosphates (CRP) Mining Project. The Chatham Rise is a submarine feature that is approximately 1000km in length, extending eastward from the South Island of New Zealand. The rise has water depths that range from roughly 80m to 500m, with the Chatham Islands near the eastern extent of the submarine feature. Just north and south of the Rise, water depths quickly approach 3000m. The main purpose of the modelling study was to investigate the turbidity generated in the water column and the deposition footprint on the seabed resulting from the mining discharge.

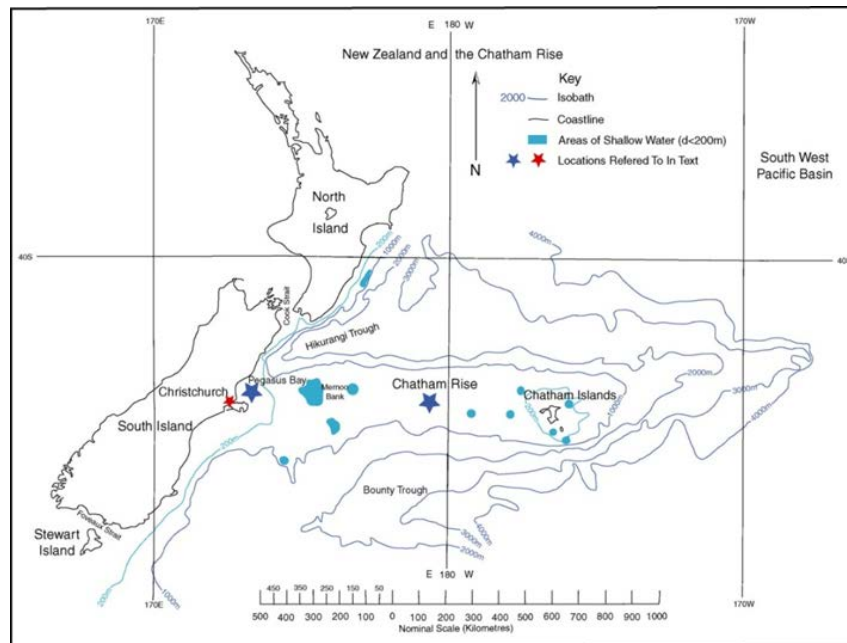


Fig. 1. Map of New Zealand and the Chatham Rise (Wikipedia: Ngatimozart, 2010).

Methodology

This study used a dedicated modelling approach to assess the near and far-field dispersion, resuspension and sedimentation behaviour of sediments. The study consisted of a far-field assessment using a Delft3D model with seasonal forcing: spring, summer and winter periods in 2011 to investigate the impact different hydrodynamic forcing had on the plume dispersion. The near-field mine tailing plume development was first investigated using a JET3D model which models the near-field plume dimensions of the spill as a result of excess density; initial momentum and ambient sea water density. The plume dimensions were then supplied to the far-field model which only considers the behaviour of the silt- and clay fractions. The models were used to examine the impact of releasing the plume at different heights above the bed on turbidity and sedimentation as well as assessing the impact of different oceanographic processes e.g. internal tides on the plume dispersion and dilution. Sensitivity tests were also performed on parameters such as the settling velocity of the fine sediments.

Results

Results of the far field modelling showed that during active mine tailings disposal, high sediment concentrations occur along the mining track. Most of these sediments (both the clay and silt) directly deposit along the track line. Plume dispersion patterns for silt in spring and winter look similar and display dispersion in a north-western direction. In the summer scenario the silt plume dispersion is somewhat larger. Maps of clay dispersion reveal considerable intra-seasonal variation in plume spreading that is similar to the predicted seasonal variation. Outside the mining area (2km-wide and 5km long region, oriented northwest-southeast) the fine sediment concentrations decrease due to plume dispersion. Both inside and outside the mining area, suspended sediment concentrations decay rapidly to values below 0.1mg/l, once mining stops; limited resuspension of deposited sediment occurs over the course of one cycle.

Both horizontal and vertical dispersion in combination with settling velocity determine the time scale over which sediment from an injected plume (re-) deposits. Dispersion is dependent on the degree of stratification therefore dispersion of the sediment plume in horizontal direction will be greater during periods of stronger stratification (but smaller in vertical direction).

The comparison of the sedimentation footprints from the different simulations point at limited effects of intra-seasonal hydrodynamic variations and cumulative effects, due to resuspension and delayed settling. Therefore the temporal variation in sedimentation pattern is much smaller than the variation observed in the suspended plume behaviour. Only data on current velocities were available for model verification but the main implications of the model performance in terms of hydrodynamics for the plume dispersion is also discussed.