ZEOLITE deposits in the Central North Island
Taupo Volcanic Zone of New Zealand

Introduction

Zeolites are open framework aluminum silicates, with exchangeable cations, mainly Na+, K+, Ca2+ or Mg2+, held within the central cavities and surrounded by water molecules. Water molecules are loosely held with most zeolites and release water on heating and then absorb water on cooling, so their cations are readily exchanged. The ion exchange and high adsorption properties of natural zeolites make them useful in a wide range of applications. Naturally occurring zeolites are formed below 200°C in wet environments. The main occurrences of zeolites are in volcanic rocks deposited as sediments in water or from airborne eruption clouds in lakes and deep sea basins. Zeolites (mordenite, clinoptilolite, laumontite and wairakite) have been known since the 1950s-1960s in the lower temperature parts of geothermal systems, such as Wairakei in the Taupo Volcanic Zone (TVZ).

More recently extensive zeolite deposits have been discovered within lake sediments less than 50,000 years old in the Ngakuru area in the TVZ. The first deposit was found in 1992 at Mangatete Road and commercial production followed soon after. Other zeolite deposits were subsequently discovered and quarries at the Mangatete and Twist Road deposits are currently in production, operated by Blue Pacific Minerals Ltd. Other zeolite deposits were subsequently discovered and quarries at the Mangatete and Twist Road deposits are currently in production, operated by Blue Pacific Minerals Ltd.

Geological setting

- The Ngakuru area lies within a NE-trending belt of active extension on the western side of the TVZ. The TVZ contains voluminous tuffs, ignimbrites and rhyolites, and minor dacite and andesite lavas, all less than 2 million years old.
- Distinctive silts are being deposited in lakes at the present day e.g. Lake Rotoma, so their occurrence in older rocks as at Ngakuru indicates that extensive lakes existed during the late Quaternary.
- The TVZ is a region of elevated heat flow manifested by numerous geothermal fields. An active geothermal field occurs at Hauhora in the NW of the Ngakuru area.
- Most of the area is underlain by the Ohakuri Formation, which is overlain by tephras (<24 ka).
- The Ohakuri Formation is overlain by the c. 64 ka Earthquake Flat Pyroclastics, which in turn is overlain by the c. 145 ka Kapenga Rhyolites.

Zeolite deposits

The deposits contain 50-80% zeolite over thicknesses of up to 45m in stratified vitric (glassy) tuffs. A ‘tuff’ is volcanic ash turned into stone and is produced by explosive volcanic eruptions. Some of the deposits are located adjacent to faults. The primary components are glass shards and pumice, with minor plagioclase, quartz and biotite crystals. Chemically the vitric tuffs are of rhyolitic composition. Some of the zeolite deposits are associated with sinter and hydrothermal eruption breccias.

Contaminated soils

The ability of zeolite to absorb heavy metals and to treat groundwater has opened up markets where contaminated soils have limited use of land. There is abundant documentation available about the use of zeolite in the remediation of soil and ground water from radioisotopes contamination from Long Island and Chemtemp, as well as recently to the Fakatupu earthquake and tidal wave. Close to homes, shakes and ground water containing heavy metals can be successfully treated with granular zeolite.

Properties

- The zeolitic tuffs are white to cream, with iron staining along joints. Dry bulk densities are mainly in the range of 0.66-1.12 g/cm3. Measured porosities are inversely related to densities and range from 45-73%, and are particularly high (55-73%) in samples from the Twist Road deposit. The very low densities are due to the voids created by the open mesh structure of the mordenite crystals.
- Cation exchange capacity (CEC) and ammonium exchange capacity (AEC) values for samples from the Mangatete deposit are in the range of 70-67 meq/100 g for CECs, 88-118 meq/100 g for AECs, with internal surface areas of 25-58 m2/g, which combine to give high liquid and odour absorption capacities.

Applications

The high cation exchange and open pore structure with high internal surface areas of the Ngakuru zeolite make it very effective in applications such as ammonium removal from waste water and in animal feeds and litterers by providing an ideal host for loading with beneficial organic or inorganic liquid waste. The same characteristics provide for an extremely efficient mechanism for the absorption of liquids and odours (predominantly ammonia) from the pet litter and oil spill markets. The sports turf market also makes use of these two main attributes, but also requires a material that is resistant to mechanical breakdown to allow it to be blended with sand. Zeolite from the Twist Road deposit provides these characteristics, hence wellington, Waikato and Dunedin sports stadia all include ~5% zeolite in the turf root zone to aid nutrient and moisture retention.

Exploration, mining and processing

The Mangatete zeolite deposit was discovered in February 1992. Exploration of the deposit was carried out by mapping and sampling, including digging of pits with an excavator. A quarry was developed at Mangatete in October 1992 by Mining Assets Ltd and was subsequently acquired by FERNZ. Following acquisition of the Mangatete quarry and associated processing plant in Taoraki from FERNZ in 1998, Blue Pacific Minerals was formed and has since expanded the operations. Additional occurrences of zeolitic tuffs were discovered and a quarry and covered drying pad and sheds have been developed at Twist Road. The quarries are worked by benches with hydraulic excavators, the raw material is crushed and screened on site and dried in the open air or under cover, before secondary processing at Tokoroa 35 km away. Secondary processing involves gas-fuelled kiln drying of the zeolite followed by crushing and screening to produce a range of products of different particle size ranges and densities. Further processing by nutrient loading onto granular zeolite for the animal feed and fertilizer industries is carried out at Blue Pacific Minerals (BPM) South Plant in Tokoroa.

Origin

The presence of sinter-hydrothermal eruption breccias and silicified fault breccias in the vicinity of the zeolite deposits suggests that they are associated with geothermal activity similar to the active geothermal systems in the TVZ. The Wairakei geothermal field contains mordenite and clinoptilolite, which formed at temperatures of 60-160°C. By analogy, mordenite and clinoptilolite in the Ngakuru deposits probably formed at similar temperatures as a result of interaction groundwater-diatomaceous geothermal water with glass shards in the vitric tuffs.

The Mangatete deposit has a 14C age of 8500 yr BP from dating of plant material in sinter overlying the deposit.

Nitrogen partitioning

Work is continuing to determine the level of nitrogen partitioning achievable using our zeolite feed to dairy cattle with reduced urea levels in urine patches on heavily farmed dairy pasture. This has a large bearing on both leaching of nitrogen in sensitive soils but also on hydrocarbon emissions. This is a worldwide problem, as is for NZ dairy farmers.

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