

MINERALOGY AND GEOLOGY OF THE MAUNGAPARERUA HALLOYSITE DEPOSIT IN NEW ZEALAND

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(Received 16 September 1976)

Abstract—The Maungaparerua halloysite deposit is located on the North Island of New Zealand some 210 km north of Auckland. The halloysite deposit was formed by hydrothermal alteration of rhyolite flow rocks. Superimposed on the hydrothermally altered halloysite is deep intensive surficial weathering resulting from the humid climate on the extreme tip of the North Island. The deposit has been drilled and the cores have been analyzed mineralogically and chemically. Drilling has shown that the deposit is circular or ovate and covers about 350 acres. The altered rocks contain about 50% quartz and fine amorphous silica and 50% of a mix of halloysite, kaolinite, and allophane with a small amount of plagioclase feldspar in the coarse fraction. The upper 8–30 m, with an average of 15 m, of the halloysite alteration deposit consists of relatively soft clay. Below this soft clay, which is the result of intense surficial weathering, the clay becomes hard and dense. The halloysite and kaolin from this deposit are mined and beneficiated using wet process techniques of dispersion, centrifugation, leaching, dewatering, and drying. The products are used as filler in paper, paint, and plastics and as a ceramic raw material for producing whiteware and fine china. This deposit is unique in that it contains a very high proportion of halloysite in the clay fraction. The detailed geology, mineralogy, geochemistry, and the physical properties of the clay will be discussed.

GENERAL GEOLOGY

The Maungaparerua halloysite deposit is located in the Northland area of New Zealand some 210 km north of Auckland (Figure 1). The landscape is relatively subdued and the rocks are deeply weathered. The mean annual rainfall over the Northland ranges from about 100 to 125 cm in the low-lying coastal districts to about 250 cm over some of the high country (Ministry of Works, 1964). The mean annual temperature in Northland ranges from 17°C to 18°C (Ministry of Works, *op. cit.*).

The oldest rocks in Northland are Permian and are greywackes, argillites, and cherts. Volcanic rocks range in age from Jurassic to Tertiary and Sedimentary rocks were deposited during Cretaceous and Early Tertiary times (Ministry of Works, *op. cit.*). In Miocene and Pliocene times the Parahaki Volcanics erupted and included dacites and rhyolites. The rhyolite has been altered to form the white halloysite clay deposit at Maungaparerua (Ministry of Works, *op. cit.*). Bowen (1966) divided the Parahaki Volcanic group into three formations on the basis of petrography: (a) Pukahi rhyolites (b) Maungarei dacite and (c) Puketaroro dacites. Longley (1973) has described the rhyolite as follows: "The rhyolite is grayish in color with a spherulitic texture containing phenocrysts of quartz, sanadine, and lesser plagioclase. The spherulites are normally small (less than 2 mm in dia.) but rare bands were noted containing spherulites to

30 mm in dia. The rhyolite is typically flow-banded and this often dips steeply. Highly contorted flow-bands can be seen in the Northern bluffs of the dome. The banding is evident even in more or less kaolinized specimens as preferential weathering and erosion has tended to pick out the layers."

The Maungaparerua deposit was derived from hydrothermal alteration of a rhyolite dome on which deep weathering has been superimposed. The area at Maungaparerua is a complex system of fractured coalescing rhyolite domes with associated flow volcanics

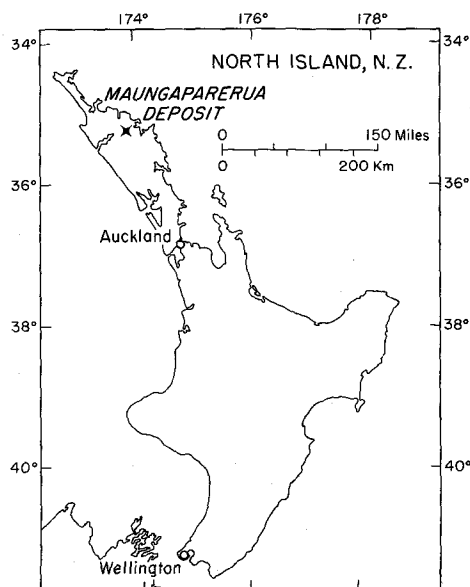


Fig. 1. Location of Maungaparerua deposit on North Island of New Zealand.

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covering large areas. The kaolin alteration is largely restricted to these domes of which Maungaparerua is one of the largest.

Basalt flows of the Kerikeri Volcanics covered the area and are evident in the vicinity; however intense weathering and erosion in post-volcanic times has largely removed the basalt cover. Red and brown loamy soils derived from the basalts cover the area and are the major overburden on the Maungaparerua clay deposit. The presence of veins, veinlets, fractures, and brecciation indicates that the area underwent intense deformation which resulted in the formation of a series of fissures and fractures of varying size. The open fissures provided channel-ways for ascending hydrothermal fluids which altered the upper portions of the rhyolite dome.

The deposit at Maungaparerua is more or less circular and covers about 350 acres. The deposit is from 600 to 700 m in dia. The rhyolite dome has a capping of soft halloysite clay under from 1 to 12 m of soft brown clay which averages about 3 m thick. The soft white clay ranges from 8 to 30 m in thickness with an average of approximately 15 m. Below the soft white clay is a hard siliceous clay of unknown thickness but a few drill holes that penetrated this zone indicated that the zone is at least 25 m thick and in one drill hole the hard whitish gray clay was penetrated from 13 to 50 m and was still in the clay when the drilling was terminated. The deepest hole was 93 m and the last few cm encountered rhyolite. The hard gray clay started at 40 m and continued to 93 m so the total thickness was 53 m.

MAUNGAPARERUA DEPOSIT

The clay deposit is comprised of about 50% silica minerals (quartz and cristobalite) and 50% clay minerals (halloysite and kaolinite, along with some allophane). Figure 2 shows the percent composition plotted against particle size. The coarse material is quartz and a small amount of feldspar. The intermediate silt size material is cristobalite, quartz, and kaolin minerals. The clay size fraction contains a very small amount of quartz and cristobalite and is mainly comprised of the kaolin minerals. The major constituent of the fine white soft clay is halloysite with a few hexagonal plates of kaolinite as shown on the electron micrograph on Figure 3. The X-ray powder diffraction pattern (Figure 4) indicates dehydrated halloysite and quartz. The differential thermal analysis curve shows that the major constituent is halloy-

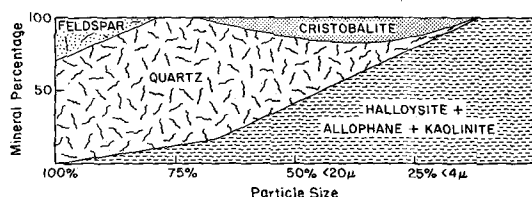


Fig. 2. Mineral composition plotted against particle size of the minerals at Maungaparerua.

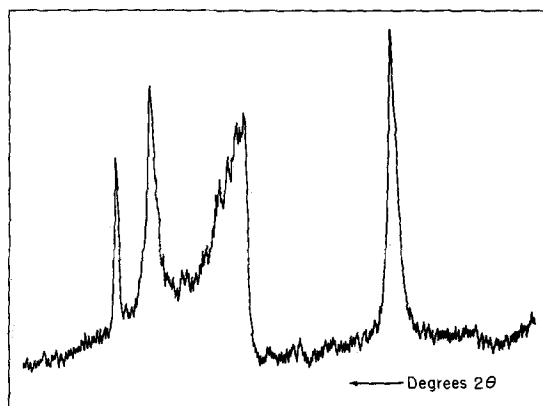


Fig. 4. X-ray powder diffraction pattern of Maungaparerua clay fraction.

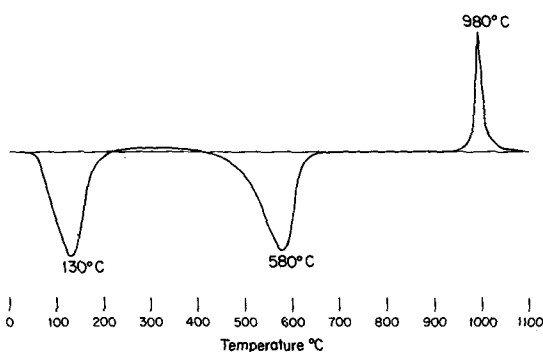


Fig. 5. DTA curve of Maungaparerua clay fraction.

site (Figure 5). The chemical analysis shown on the following table is a representative sample of the soft white clay.

The analyses, shown in Table 1, indicate that quartz and feldspar along with some iron oxides are removed during the processing which involves particle size fractionation and chemical leaching to remove iron. The processed clay is about 90% less than 2 μm in size. The brightness of the raw clay was 87% and the processed clay 90.2% as measured with a General Electric brightness tester.

Surface area measurements using the standard B.E.T. method was 16 m^2/g for the raw clay which had been degritt and 27.8 m^2/g for the processed clay. These values are much higher than for Georgia kaolinite which would be of the order of 7 m^2/g

Table 1. Chemical analysis of Maungaparerua clay

	Crude clay	Fine processed clay
SiO ₂	66.30	47.4
Al ₂ O ₃	23.33	38.1
Fe ₂ O ₃	0.76	0.40
TiO ₂	0.23	0.32
CaO	0.21	0.10
MgO	0.17	0.14
K ₂ O	0.32	0.02
Na ₂ O	0.30	0.08
Ignition loss	8.26	13.73
Total	99.88	99.99

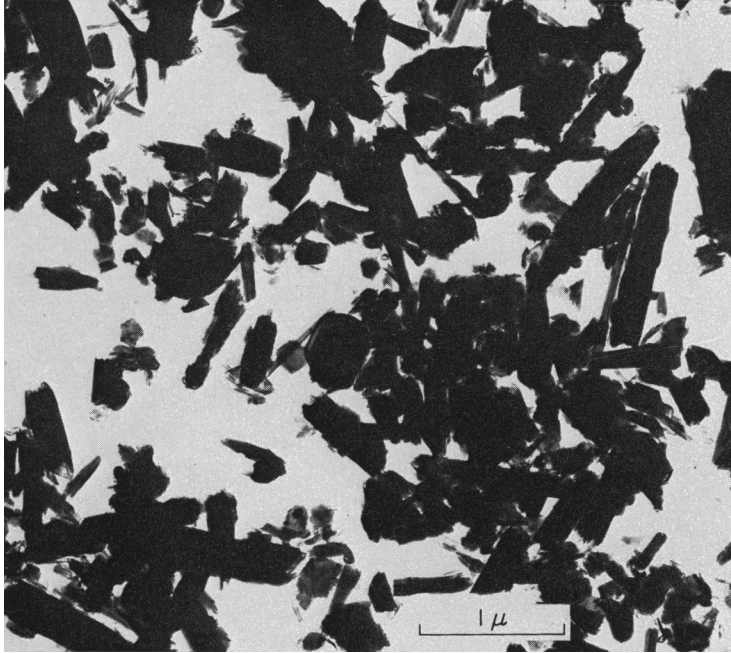


Fig. 3. Electron micrograph of clay fraction of Maungaparerua.

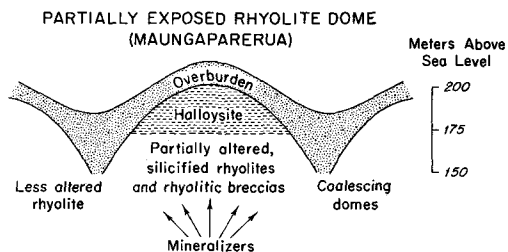


Fig. 6. Diagrammatic section showing alteration.

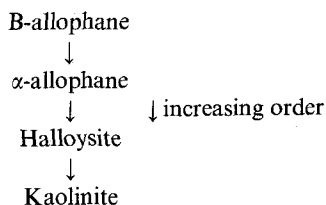
for degrittred crude clay and 12 m²/gm for a standard kaolin coating clay with a particle size of 90% finer than 2 μm. These high values must be the result of the large percentage of halloysite and the presence of allophane.

Allophane contents were determined using the method of Hashimoto and Jackson (1960). For the degrittred crude clay the allophane content was 26.2% and for the fine processed clay was 32.3%. The clay is very reactive chemically as compared with Georgia kaolins which corroborates the presence of halloysite and allophane.

From electron micrographs, DTA, and X-ray powder diffraction the major kaolin clay mineral present is halloysite along with about 30% amorphous material called allophane.

GENESIS

The halloysite and allophane were formed by the alteration of acid volcanic rocks of the Parahaki group. The feldspar minerals in the parent rhyolite have been altered by the ascending mineralizing solutions to allophane, halloysite, and a small amount of kaolinite. Figure 6 shows a partially exposed rhyolite dome, the top of which has been completely altered by the ascending mineralizing solutions. Figure 7 shows a generalized cross section with brown clay overlying the soft white clay, which in turn is above a harder gray clay. This sequence is interpreted to mean that the descending surface water has further altered the clay which accounts for the soft white clay overlying the hard siliceous gray clay. Harvey (1967) has proposed that the feldspar breaks down to amorphous oxides. The amorphous oxides then combine to form allophane, the silica minerals, and iron oxides. He proposed that there is a sequence of increasing crystallinity shown as follows:



The relationship and sequence of minerals in the Maungaparerua deposit indicate that the order of mineral formation proposed by Harvey may be correct in this particular instance.

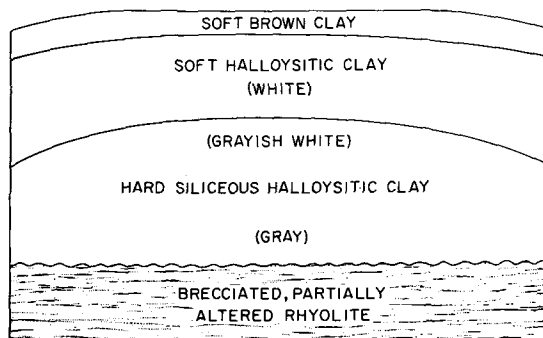


Fig. 7. Generalized cross section of Maungaparerua clays.

ECONOMIC USES

The white halloysitic clays are mined and processed from the Maungaparerua deposit and other deposits in the area into products that are used as fillers in paper and paint and as a ceramic raw material for producing whiteware and fine china. Drilling has shown that there is over 10 million tons of clay in the Maungaparerua deposit so that a sizable mining and processing operation could be sustained for many tens of years. Future processing might include calcination, which would produce an extremely bright product of 94% or higher which could be used as a very white filler to replace TiO₂. The fact that this clay is so reactive to acid and bases make it likely that the material could be useful as a catalyst raw material in the future as markets develop in Southeast Asia and Australia.

CONCLUSIONS

1. The Maungaparerua halloysite deposit formed by hydrothermal alteration of rhyolite.
2. Intense weathering has further altered the deposit forming the soft white cap of halloysite.
3. The halloysite clay is extremely white and a large tonnage has been proven and additional uses can be developed for this unique material.

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