INTRUSION OF MIOCENE DIKES INTO WET TEPHRA, KAIPARA HARBOUR, NORTHLAND NEW ZEALAND.

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ABSTRACT

Several subvertical dikes of quenched and chilled basalt intrude a submarine tephra and underlying Miocene sediments on the north shore of Okahukura peninsula, Kaipara harbour, west coast of Northland, New Zealand.

Results of simple physical modelling show that a number of structures, complex at first sight, i.e. rim dikes and horns, fingers, sigmoidal and rhomboidal intrusives (the three latter named internal intrusives) and peperites form in sequence when the dikes stop and cool. Rim dikes and horns are formed at an early stage as dike tips are blunted as a result of consolidation of tephra when the pore water pressure dissipates. Internal intrusives and at last peperite are interpreted as volume of expelled magma consecutively to the change from liquid to the more voluminous solid+gas states of the magma as the dikes cool. The tips of the dikes act as a pressure valve because, in such sheet intrusion, an increase in the internal pressure is magnified some thirty times at the tip. After the dikes had solidified, the tephra ahead of dike tip was fluidized by vapor flow.

Two dikes intruding the tephra are selected for mechanical modelling. Preliminary results show that the tephra was not cemented. It is modelled as a sand with a hyperbolic stress vs strain relationship which changes with the stress path. The dikes are treated as flat elliptical cavities. It is shown that the presence of an array of cracks in the tephra ahead of the dikes can be simulated with the Barenblatt-Dugdale model of fracture mechanics and that the width of the elliptical slit used in calculation must be wider than that of the dikes. The driving pressure of these two dikes was approximately 4 MPa and elastic displacement 25 to 30 % of total displacement.

The tephra is the remnant of a dissected but structurally intact shallow submarine volcano of surtseyan type. Results of the mechanical modelling and structural and sedimentological data enable to localise the main vent of the volcano.

The surtseyan cone, which consists of tholeiite, overlies unconformably all other Tertiary formations. This confirms that, along the west coast of Northland, the latest lower Miocene manifestation of high alumina volcanism occurred in Mid-Upper Altonian times (17.5-15.5 My) and was basic and tholeiitic.

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TABLE OF CONTENTS

NOMENCLATURE OF VOLCANIC ROCKS. DEFINITION OF SOME OF THE TERMS USED IN THIS THESIS (alphabetic order).

Agglomerate. Accumulation of coarse volcanic material very proximal to, or infilling a vent. The form of the fragments is a primary feature determined during the actual eruption (Wentworth & Williams 1932).

Drusy vesicles. Small intersticial voids of irregular shape entirely or partially filled with clay minerals; not visible in hand specimen (= intersticial voids in Barragard & Al 1977, vuggy porosity in Anderson & Al 1984).

Hyaloclastite. The term is employed in this thesis in the restrictive sense proposed by Rittman (1962 p.72) and Honnorez and Kirst (1975) i.e. formed by granulation of basaltic glass by thermal shuttering only. The term is also used for glassy tuff by some other workers. It will be written between quotation marks when cited from literature with this more general meaning.

Palagonitisation. Alteration and induration of a pile or part of a pile of sideromelanitic material. The margin of clasts is hydrated and coated with smectite and zeolites. (e.g. Honnorez 1972).

Peperite. Breccia formed of fragments of volcanic glassy material in a sedimentary matrix. The term has the genetic implication that the mixing occurred during intrusion of magma in wet sediments (Wentworth & Williams 1932). It must be noted that the peperite of limagne (Massif central, France) for which the term has been used first are actually infilling of maar vents (Tricot 1975).

Pyroclastic. Umbrella term for detrital material which has been expelled from a vent; may have been secondarily compacted (Rittman 1962 p.74).

Segregation vesicles. Vesicles lined with dark tachylite always finer grained than surroundings and interpreted as residual melt (Smith 1967).

Sideromelane. Transparent (in thin section) variety of basaltic glass lacking an opaque phase and formed by quenching (e.g. Fuller 1932).

surtseyan. said of eruption occurring in shallow water environment and forming tuff cones of glassy material. The name refers to the eruption of the Surtsey volcano well documented by Thorarisson (1969).

Tachylite. Glass of basaltic composition rendered semi-opaque to opaque by the presence of dust or neddle-like crystals and formed in a chilling environment beneath an insulating layer of sideromelane (e.g. Fuller 1932, Schiffman & Lofgren 1981).

Tephra. Fragmental material torn off and ejected in solid or molten condition by gas of an eruption (e.g. Rittman 1962 p.74). Following Thorarisson (1969), the products of surtseyan eruptions are referred to as submarine and subaerial tephra.

Vesicle. In this thesis the term is employed for bubbles partly filled with some kind of matter. They may have an irregular shape.

SAMPLE NUMBER

The samples referred to in this thesis are lodged in the University of Auckand as (as example) :

M2290 : reference number of specimen housed in the mineral collection of the Geology department.
40027 : reference number of rock sample housed in the reference collection of the geology department.

LIST OF PRINCIPAL SYMBOLS

α : Coefficient of isobaric thermal expansion ($^{\circ}C^{-1}$).
β : Coefficient of isothermal compressibility (Pa^{-1}).
γ : Stress gradient; Eq.9.4 ($Pa.m^{-1}$).
δ : Interval non loaded by internal pressure at the extremity of pressurised crack; p.8-41 (m).
ε : Strain.
$\dot{\varepsilon}$: Strain rate (s^{-1}).
η : Viscosity (Pa.s).
θ : Normalised temperature, Eq.9.2.
θ_D : Normalised temperature, appendix 8C.
λ : Normalised position of the liquid-vapor interface of pore fluid = particular value of ω .
μ : Shear modulus (Pa); $\mu = E/2(1+v)$.
ν : Poisson ration ($\nu = -\varepsilon_3/\varepsilon_1$)
π : Ratio of the circumference of a circle to its diameter.
ρ : Density (Kg/m^3).
σ : Stress (Pa).
ψ : Normalised pressure along heated surface, defined in appendix 8C.
ω : Normalised distance normal to heated surface, defined in appendix 8C.

A : Pore pressure coefficient of Skempton for deviatoric loading (p.7-23).
A_D : Driving term of thermal expansion, Eq.9.9.
B : Pore pressure coefficient of Skempton for isotropic loading (p.7-22).
D : Mass diffusivity (m^2/s).
D_D : Ratio of thermal to hydraulic diffusivity defined in appendix 8C.
d_b : Diameter of bubble (m).
E : Young modulus, E_i=initial, E_{UR}=unloading-reloading (Pa); $E=2(1+\nu)\mu$.
G : Constant proportional to the stress gradient (Eq.6.1).
K : Distribution coefficient of a solute between crystal and

liquid.
K_I : Stress intensity factor, tension, Eq.8.4 ($Pa.m^{1/2}$).
K_p : Permeability (m^2)
L : Length, fig.5.2 (m).
n : Porosity.
P : Pressure (Pa).
P_d : Driving pressure (Pa).
P_m : Magmatic pressure (Pa).
q : Discharge velocity of pore water, Eq.9.11 (m/s).
R : Radius (m).
R : In section 10.2.10, gas constant.
$\dot{R}$: Rate of advance of front of crystallization (m/s).
S_1, S_3 : Maximum and minimum regional stresses (Pa).
T : Temperature, T_m=magmatique, Tc=contact, T =host rock (°C).
t : Thickness, fig.5.2, t_o=at centre of ellipse (m).
t_s : Time (s).
U : Pore pressure (Pa).
ΔU : Variation of pore pressure (Pa).
V : Volume (m^3).
Vl : Velocity (m/s).
υ : Displacement, υ_c=consolidation, υ_D=deviatoric, υ_{UN}=undrained, υ_{oed}=oedometric (m).
W : Width, fig.5.2 (m).
X_k : Normalized stress intensity factor (Eq.8.9).