

**SUMMARY OF THEORY AND TECHNIQUES, SAMPLE SELECTION AND PROJECT
ORGANISATION FOR POTASSIUM-ARGON, RUBIDIUM-STRONTIUM AND FISSION
TRACK DATING AND STRONTIUM ISOTOPE STUDIES**

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ABSTRACT

A brief outline is given of the theory and techniques of the potassium-argon, rubidium-strontium and fission-track dating methods and related isotope studies which are currently in use at the Institute of Nuclear Sciences, DSIR. Some limitations of each technique are set out in terms of age range and materials for dating, and the appropriate choice of various mineral and rock types and subsequent age interpretations are discussed.

The organisation of project proposals and categories is described and procedures for sample submission and documentation are given.

KEYWORDS

GEOCHRONOLOGY; K/Ar; Sr/Rb; FISSION TRACK DATING; STRONTIUM ISOTOPES

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INTRODUCTION

Potassium-argon (K-Ar), rubidium-strontium (Rb-Sr) and fission track dating, developed at the Institute of Nuclear Sciences, are the most versatile methods for geochronological studies in New Zealand. This report briefly outlines technical aspects and selection procedures for K-Ar, Rb-Sr and fission track dating studies, and the way in which these projects should be organised.

The K-Ar method remains the most widely used technique because it has applications to most classes of rocks and minerals over the whole geological time-scale (an extreme younger age limit would be 5,000 years). Rb-Sr dating is restricted to fewer rock/mineral types and its application in geochronology is mainly in studies of rocks older than 25 Ma.

Allied to the Rb-Sr dating method, is the use of $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in rocks for petrogenetic studies. These ratios reflect the ancestry of igneous rocks in terms of the Rb content and age of their pre-cursors and/or their various origins in the earth's crust or mantle.

Fission track dating, based on the spontaneous fission of ^{238}U , is most suitable for Mesozoic-Cenozoic sequences. It is used for absolute dating of samples which are unaffected by heat subsequent to formation, but because of the relatively low annealing temperatures of some minerals e.g. apatite, it can be an important tool in thermo-tectonic studies (burial histories etc.).

THEORY AND TECHNIQUES

The K-Ar method

This dating technique relies on the weak natural radioactivity of the rarest isotope of potassium, ^{40}K , ($^{40}\text{K}/\text{K} = 0.01167\%$), which decays by β -decay (decay constant $\lambda_{\beta} = 4.962 \times 10^{-10}\text{yr}^{-1}$) to ^{40}Ca and by electron capture, positron emission and several γ -rays (decay constant $\lambda_{\epsilon} = 0.581 \times 10^{-10}\text{yr}^{-1}$) to ^{40}Ar . The branching ratio $\lambda_{\epsilon}/\lambda_{\beta}$ of this dual decay is 0.117 i.e. 10.5% of decays is to ^{40}Ar . The half-life of the ^{40}K is 1.25×10^9 yrs.

The ^{40}K - ^{40}Ca decay branch is rarely used in geochronology because of technical difficulties with calcium mass spectrometry and the measurement of small amounts of radiogenic ^{40}Ca in the presence of large quantities of initial ^{40}Ca (i.e. present in the rock when formed), which is the commonest isotope (97%) of calcium, itself an abundant rock forming element.

In contrast, argon is a very rare constituent of rocks and because of its gaseous, inert character, even tiny quantities of ^{40}Ar (10^{-10}) are readily measured by modern mass spectrometric methods. However, argon is an important constituent (0.934%) in air and ^{40}Ar is by far the

most abundant argon isotope ($^{40}\text{Ar} = 99.60\%$, $^{38}\text{Ar} = 0.06\%$, $^{36}\text{Ar} = 0.34\%$); thus atmospheric argon contamination of rocks and minerals (both during geological time and during laboratory analysis) is potentially a very serious problem. This is especially so in the case of young rocks, where the quantities of ^{40}Ar (radiogenic) extracted from rocks are comparable with any residual atmospheric argon in ultra high vacuum (UHV) apparatus and mass spectrometers, or atmospheric/radiogenic argon actually dissolved in silicate melts, for example volcanic lavas during eruption. However atmospheric argon has a constant ratio $^{40}\text{Ar}/^{36}\text{Ar} = 295.5$ and hence ^{36}Ar contents can be used to discriminate between radiogenic and non-radiogenic ^{40}Ar . Since the ^{36}Ar quantities are themselves extremely small, the accuracy of their measurement becomes the principal factor in the errors of age determinations of very young (<1 Ma) rocks.

The radiogenic argon in rocks and minerals is extracted, purified and measured under ultra-high vacuum conditions to minimise atmospheric argon contamination. The argon quantities are determined by an isotope dilution procedure which involves the addition of an artificially enriched rare isotope of argon, ^{38}Ar , (the 'spike') as a tiny aliquot (0.4×10^{-9} l) from a precision gas pipette, to the argon (radiogenic + atmospheric) extracted from a rock by melting in vacuo with an RF induction heater. The argon isotopes are separated from contaminant gases by a molecular sieve to remove polar molecules (H_2O , CO_2 , etc) and hot titanium to remove chemically active gases. (O, N, SO_x , NO_x , Cl, F, H, CO, CH_4 , etc). Purified argon is then measured on a small automated mass spectrometer as ^{36}Ar (mainly atmospheric) ^{38}Ar (spike) ^{40}Ar (mainly radiogenic + atmospheric).

Potassium is analysed by a flame spectrophotometric method by comparison with pure potassium hydrogen phthalate standards. Potassium is extracted from rocks by HF/HNO_3 digestion in stainless steel/PTFE pressure vessels and cation exchange separation in acid media (HNO_3) on analytical grade Dowex-type ion exchange resins.

Choices of minerals for dating

The choice of rock or minerals for K-Ar dating is influenced by two important assumptions relevant to the method 1) no argon (^{40}Ar) is present in the rock and mineral at the time of formation ($t = 0$) and 2) the rock and/or minerals remain closed systems throughout their lifetime (i.e. no gain or loss of Ar or K). The lattice structure of some framework silicates has a bearing on the first assumption and the diffusion characteristics of argon and structural location of K in minerals have a bearing on the second.

Micas

Biotite and muscovite are widespread in plutonic and higher grade metamorphic rocks (and to a less extent in volcanics) and are hence the best and most reliable materials for K-Ar dating. Their high K contents and excellent ^{40}Ar retention characteristics mean that they can be used through the widest geological time-range. However, their argon retention temperature can be as low as 250-350°C, which is well below the temperature of crystallisation of most rocks (time of formation) and represents a later event, during the cooling stage of a rock sequence. In geological situations where this cooling interval is protracted (for example, the uplift stage of orogenic belts) then biotite and/or muscovite mineral ages have to be interpreted, a priori, as 'cooling' ages.

Amphiboles

Amphiboles in general, and hornblende in particular (K content 0.5-1.0%), have higher argon retentivity than micas and are therefore more resistant to thermal overprinting of a younger geological event upon an older one that is being dated. Radiogenic argon begins to accumulate in hornblende at high temperatures, ~400°C, and in metamorphic terranes where slow cooling histories may cause significant age discordances, hornblende ages approximate more closely than micas to an original rock forming (crystallisation) event.

Pyroxenes

Low potassium contents of pyroxenes, generally less than 0.2%, limit their usefulness for dating, despite high argon retentivities. They have an open three dimensional lattice structure, which allows some incorporation of gases under high pressures. In common with similar silicate structures, such as found in beryl, cordierite and some feldspathoids, these minerals can absorb 'excess' argon (with other gases) i.e., that not produced by in situ decay of ^{40}K and measured ages are therefore usually far too old and quite spurious.

Feldspars

Orthoclase, anorthoclase, microcline and adularia may have very favourable potassium contents (8-10%) but their argon retentivity is poor and the diffusion mechanism complex (K may be held in two different energy sites in the feldspar lattice). Such feldspar ages are thus frequently younger than anticipated and demonstrate the ease with which relatively minor and mild geological events subsequent to rock formation can cause significant argon loss.

Amongst the feldspars, sanidine is an important exception and high temperature (volcanic) sanidine is an excellent geochronometer. Because of its high K-content (up to 10%) and argon retentivity, it allows dating of volcanic rocks as young as 8000 years.

For reasons similar to the low-temperature K-feldspars mentioned above, plagioclase feldspars are also unreliable for dating and their low (<0.5%) potassium contents are a further drawback which adversely affects errors of young (<1 Ma) ages.

Glauconite

The complexity of glauconite structure and paragenesis makes K-Ar dating of glauconites rather controversial. Glauconite undergoes several mineralogical changes during sedimentary rock formation and each involves partial K loss/gain and potential argon loss (and ages younger than anticipated). They are susceptible to even slight disturbance during diagenesis and burial metamorphism. The most reliable glauconite varieties are those which have low-Fe, high-K (>6%) and a relatively ordered muscovite-like lattice structure. In a few cases, glauconite formation is known to proceed by degradation of pre-existing phyllosilicates, such as biotite and chlorite and in these cases the new glauconite may inherit radiogenic argon and yield ages that are demonstrably too old.

Whole-rock dating

Potassium-argon dating of whole-rock samples is reliable if they contain favourable potassic minerals and are very fresh. It is frequently the case that whole-rock dating has to be attempted on rocks too fine for mineral separation, for example aphyric volcanic rocks. Although often fresh, such rocks may have an unreliable component, the interstitial volcanic glass, that is quite potassic and which may have altered, devitrified or dehydrated with time and consequently lost significant amounts of radiogenic argon.

Influence of rock texture

Diffusive argon loss in minerals follow an approximate, simple spherical volume diffusion model and the quantitative effects are consequently greater for finely crystalline rocks. For a given thermal impulse, coarse micas would be less affected than fine ones. It is therefore advisable to collect representative samples for dating at the coarsest possible grain size - thin section examination and mineral separation are then also much easier. Sample size must also take into account the modal mineral proportions and grain size but minimum representative sample weights of fresh rock for dating are given below :

Grain Size	Texture	Representative Sample Wt.(kg)
>30 mm	Pegmatitic	5
1.0-30 mm	Coarse	2
0.1-1.0 mm	Medium	1
<0.1 mm	Fine	0.5

When choosing samples, preference must be given firstly to the freshest rocks available, with the minimum textural 'complications' such as dense jointing, pervasive weathering, veining, patchy alteration, inclusions, vesicles, xenoliths etc; secondly, to coarsely crystalline rocks in which mineral proportions are favourable and easily assessed and thirdly, to rocks with abundant muscovite, biotite, sanidine (volcanic) or hornblende. Where possible it is best to avoid strongly feldspathic, feldspathoidal, zeolitic and carbonate-rich rocks. Samples should also be taken as one piece.

The Rubidium-Strontium method

Much of the theory and application of the K-Ar method briefly outlined above applies to Rb-Sr dating. This method depends on the natural radioactivity of ^{87}Rb (27.8% of common rubidium) to ^{87}Sr by β -decay ($\lambda_{\text{Rb}} = 1.42 \times 10^{-11} \text{yr}^{-1}$) with a half-life of 4.8×10^{10} yrs. The age determination requires the measurement of ^{87}Rb and ^{87}Sr (radiogenic) quantities in the rocks on the assumption that they have remained closed system, with respect to both since the time of crystallisation. For technical reasons it is easier to refer both to a common denominator, ^{86}Sr , so that the quantities become ratios i.e. $^{87}\text{Rb}/^{86}\text{Sr}$, obtained from the Rb/Sr ratio measured for example by XRF spectrometry, and $^{87}\text{Sr}/^{86}\text{Sr}$ which is simply determined by solid-source mass spectrometry. However, unlike the K-Ar method, where an assumption that no radiogenic isotope, ^{40}Ar , is present in rocks at the time of formation, this is not true of ^{87}Sr , which is present in all strontium associated with the common rock-forming element calcium. It is therefore necessary to make assumptions about the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio in a rock, or measure this from a Rb-free phase present (such as plagioclase) or to calculate it independently from several samples of the same rock unit which are demonstrably of the same age (i.e. t is constant) and origin [$(^{87}\text{Sr}/^{86}\text{Sr})_i$ is constant] but which have slightly different Rb and Sr contents (i.e. variable Rb/Sr ratio). Results are graphically displayed using a Rb-Sr isochron diagram ($^{87}\text{Rb}/^{86}\text{Sr}$ v $^{87}\text{Sr}/^{86}\text{Sr}$) from which a

linear array (isochron) has a slope proportional to the rock age and a $^{87}\text{Sr}/^{86}\text{Sr}$ intercept equal to the initial Sr isotopic composition.

Rb-Sr dating of minerals follows the same general principles and restrictions as for K-Ar dating but it is usually only high-Rb minerals such as sanidine and micas that are confidently used for dating. However, whole-rock samples (which have a much larger diffusion domain size than the component minerals) are essentially closed systems with respect to Rb and Sr under most geological conditions subsequent to crystallisation and are widely used for isochron age determinations. However, numerous (say 25-30) large, 2-5 kg, samples have to be collected to search for some variation in the Rb-Sr ratio, and yet they must be sufficiently closely associated in the field (say on the large outcrop scale, ~ 500 m) to be confident that they are all definitely of the same age and had the same initial Sr ratio. These criteria are usually met with igneous rocks and more rarely for higher grade metamorphic rocks (upper greenschist facies and above). The mechanisms that produce initial strontium isotopic homogenisation for sedimentation/diagenetic and burial metamorphic processes are uncertain and isochron ages are therefore far less predictable and convincing.

Strontium isotopic studies in petrogenesis

The isotopic composition of strontium changes continuously because of the decay of ^{87}Rb to ^{87}Sr and the rate of change is proportional to the Rb/Sr ratio of the system in which strontium resides. Therefore, rocks and minerals in the earth's crust and mantle acquire $^{87}\text{Sr}/^{86}\text{Sr}$ ratios which reflect their Rb/Sr ratio and age. The isotopic composition of strontium in rocks thus has an increasingly wide range throughout geological time. However, various geological processes continuously destroy rock sequences and recombine them to form new ones which then inherit strontium distinctive of earlier generations. Initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of igneous rocks thus contain a record of the Sr isotope history of its ancestors and Rb-Sr studies can be used not only to measure the geological age but also provide information about their previous geochemical history. Other isotopic ratios involving radiogenic isotopes such, as $^{143}\text{Nd}/^{144}\text{Nd}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$ and $^{208}\text{Pb}/^{204}\text{Pb}$ are frequently used in conjunction with or in addition to $^{87}\text{Sr}/^{86}\text{Sr}$ measurements.

As for other geochronological studies, rock samples should be fresh and large enough to be homogeneous and representative. To determine the Sr isotopic composition of an igneous rock suite fully, it is frequently necessary to make several determinations to investigate a) homogeneity within individual rock bodies, e.g. plutons or lavas b) extent of differences between similar units c) range of composition for all units under examination. Consequently, projects range from a minimum suite of 10-15 analyses, to a major study requiring 50-60 analyses.

The main isotopes of 'common' strontium are ^{88}Sr (82.5%) ^{86}Sr (9.9%) ^{87}Sr (7.0%) and ^{84}Sr (0.6%). Total Rb and Sr are usually measured by XRF spectrometry but where concentrations are low (<10 ppm) an isotope dilution procedure using enriched ^{84}Sr and ^{87}Rb spikes may be used. Mass spectrometric analysis of the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio is done on a solid-source mass spectrometer with a typical precision of 0.005%. Rb and Sr are separated from rocks and minerals by dissolution in HF/HNO₃ in stainless steel/PTFE pressure vessels, followed by cation-exchange separation in acid media (HCl) on Dowex 50-X-8 ion exchange columns. Pure Rb and Sr is then evaporated on to outgassed and etched single tantalum mass spectrometer filaments.

Fission-track dating

This technique is based on the spontaneous fission of ^{238}U . The fission products recoil in opposite directions, disrupting the electron balance of the atoms in the mineral lattice along their path to form damage trails within the crystals. Treatment with suitable etchants enlarges the trails so they are visible through a petrographic microscope. The number of fission tracks is proportional to the uranium content and to the age of the mineral. The uranium content is determined by bombarding the samples with a neutron flux which induces fission of ^{235}U .

The age of the mineral or glass is calculated using the following formula :

$$\text{Age} = \frac{1}{\lambda_D} \ln \left(1 + \frac{\rho_S \lambda_D \sigma I \phi}{\lambda_F \rho_I} \right) \text{ years}$$

where ρ_S = fossil track density from ^{238}U fission

ρ_I = neutron induced track density from ^{235}U fission

λ_D = total decay constant for ^{238}U
 $= 1.551 \times 10^{-10} \text{y}^{-1}$

ϕ = neutron fluence

σ = cross section for thermal neutron induced fission of ^{235}U
 $= 580 \times 10^{-24} \text{cm}^2$

I = atomic ratio $^{235}\text{U}/^{238}\text{U}$
 $= 7.252 \times 10^{-3}$

λ_F = decay constant for spontaneous fission of U

Because of the variability in values determined for λ_F and the difficulty of assessing ϕ accurately, their use is avoided by dating age standards and standard glasses. Standards used in this laboratory are zircons from the Fish Canyon Tuff, age 27.9 Ma, in conjunction with NBS SRM 612 glasses.

Age Range

Fission track dating can be used to date geological materials ranging from Palaeozoic to Upper Pleistocene, depending on the uranium content of the minerals used. If a high concentration of uranium is present the tracks may be too densely distributed to count in older, whilst minerals with little uranium, statistical errors in counting the few tracks in young minerals become very large.

Minerals commonly used

The most commonly used minerals are apatite, zircon and sphene. Volcanic glass (glass shards or obsidians) can also be dated, but with caution because fission tracks in glass are unstable at room temperature. Correction techniques are possible but are very time consuming and unless glass is the only way of obtaining an age estimate, it is best avoided.

Fission tracks in the mineral phases are unstable at higher temperatures. For apatite this temperature is of the order of 105°C, for zircon current estimates lie between 175 and 240°C, and for sphene 250°C. This property has allowed fission track dating to be used in studies of thermo-tectonic histories. (For this reason there must be no heat treatment of any form during the preparation of fission track samples).

PROJECT ORGANISATION

Rock samples for dating are usually grouped into small projects (usually about 10 samples, maximum 20) for which a reasonable short analytical turn-around time can be predicted. However these projects can be a single stage in a longer programme where it is convenient to complete and review a first stage before proceeding to the next.

Project categories

A. External Projects

Where a project is initiated and organised solely by scientists outside INS and in particular (a) those in government departments outside DSIR, (b) private individuals and commercial organisations in New Zealand and (c) all organisations overseas, then age determinations will be charged for at a rate which reflects operating material costs, technical/scientific salaries and capital costs. For small batches, samples in this category will normally have a turn-around time of two months (six months for fission track), unless notified to the contrary at time of submission.

If samples originate in New Zealand territories, and the contributor is prepared to allow INS to make the data openly available after two years, then a 20% discount on charges will normally apply.

B. INS-DSIR-University collaborative projects

Where a project is organised collaboratively between scientists in INS and other DSIR divisions or university departments and participation in practical research and/or subsequent publication is approximately equal, then charges for age determinations will be 30% of full charges. However, INS will determine project acceptability and priorities, and will require reasonably prompt and acceptable publication of results within 2 years of completion. After this period age data will be openly accessible. Collaborating organisations which can arrange to assist with technical work at INS will be given higher priority, where feasible. DSIR and university projects should be submitted in category A where a high priority or confidentiality is demanded.

C. INS Research Programmes

An important part of the Geochronology programme involves INS's own research projects. Where scientists outside INS are asked to contribute to these projects, then charges for age determinations will not be made. The research of students working nearly full time at INS would normally be considered in this category.

Project documentation

Each project is briefly described on a Project Details form to aid strategic planning and to integrate all projects efficiently into the larger programmes of the geochronology group at INS. The Project Details should be as follows (see example in Fig. 1) :

Figure 1

INSTITUTE OF NUCLEAR SCIENCES.

Geochronology Project : Project Details

Date : 1/3/87

1. Project Title :

Barrytown Granite

2. Collaborators :

A.J. Tulloch

Organisations :

N.Z. Geological Survey (Lower Hutt)

3. Project outline :

Age of the Barrytown granite. This small pluton intrudes low-grade Greenland Group metasediments with a narrow thermal aureole. K-Ar ages of Greenland Group slates nearby are old, >400 Ma and unaffected by widespread Cretaceous granitoids in the Paparoa Range immediately to the north. The Barrytown granite may therefore be an isolated example of earlier plutonic phase of Tuhuan (Devonian-Carboniferous) granites in the Paparoa Range.

K-Ar mineral ages are required first, possibly followed by Rb-Sr whole-rock isochron dating, to determine the age of granite intrusion and any possible later thermal overprint. The ages would also date associated tungsten mineralisation in the granite.

4. References, maps :

NZGS 1:250,000 Buller sheet.

5. Sample List : Summary

INS R.No	Contr. No.	Sample Details	Location	Grid. Ref.
1	85/221	<i>Biotite-granodiorite</i>	<i>Canoe Ck</i>	<i>S37/852154</i>
2	85/223	" "	"	<i>S37/854153</i>
3	85/225	<i>Granodiorite</i>	<i>Barrytown Br.</i>	<i>S37/843133</i>
4	85/226	"	<i>Granite Ck</i>	<i>S37/844133</i>
5	85/227	<i>Biotite-granodiorite</i>	"	<i>S37/845132</i>
6	85/228	" "	"	<i>S37/845132</i>
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

6 : Checklist :

Revenue/Non-revenue?	<i>Non-revenue</i>	
All sample details forms checked?	<i>Yes</i>	
Thin sections available?	<i>Yes</i>	
Rock samples available?	<i>Yes</i>	
Location map for samples available?	<i>Yes</i>	<i>NZMS1 537</i>

1. Project Title
2. Collaborators Full names
Organisations Formal affiliation or organisation
3. Project Outline This should be about 100-200 words long and briefly describe :
 1. The geological basis for the project
 2. The main aim of the dating project
 3. The proposed methods and samples suggested for the project.
4. References Journal or map publications, thesis or report references are essential. A good topographic/geologic map showing location of samples will be expected.
5. Sample List - summary

This is a brief tabulation of the rocks that will be submitted for dating, showing the contributor's sample numbers, sample names, locations, map grid references (or Lat/Long). The INS sample R-numbers are entered when the project is accepted.

6. Check-list

This is for the contributor to be clear that the following information is organised :

1. Revenue/Non-revenue? Will this project attract income from outside the contributor's organisation? If so, then INS may charge that organisation for all analytical services provided.
2. Are completed sample forms available for all the rocks that you propose to submit? No samples are accepted otherwise.
3. Are petrographic thin-sections available? INS does not have thin-section making facilities and these may be required at the earliest stages of project evaluation (before any rock samples are sent).
4. Are all the rock samples definitely available? Hypothetical samples still on the outcrop are not considered! Samples not collected in situ will generally be unacceptable.

5. Is a location map prepared? Ideally a xerox copy of a 1:50,000 or similar scale topographic and/or geological map will be satisfactory, with sample location and field numbers clearly indicated. This should be attached to the project details form.

When project proposal forms have been completed these should be sent to INS (or via a liaison officer) for evaluation. At this stage, it is worthwhile to include location maps, relevant references and petrographic thin sections.

SAMPLE DOCUMENTATION

When the technical feasibility, project priority and appropriate charging category details have been established, then the rock samples can be sent to INS with accompanying sample details forms. The sample details forms are laid out in a strict pattern and provide the basis for data entry on to the main VAX database at INS. Contributors remain responsible for the completeness and accuracy of Sample Details forms. The data fields required are as follows (see example, Figure 2):

INS R. No.

This is the accession number for the main INS sample catalogue and will be entered at INS. It relates to K-Ar, Rb-Sr and fission-track collections, as well as ^{14}C , stable isotope research samples etc. (cf. NZ Geological Survey f-series and p-series numbers).

Rock Type

This has about three data fields, only the first being computer-searchable, separated by semi-colons :

Field 1 : This must be a rock name (max. 80 characters). This field will be searchable for archive purposes and hence a simple generic rock name is preferred to exotic homonyms. A good list is given by Reed (1964) and slightly abbreviated in Appendix 2.

Field 2 : Textural information, e.g. colour, grainsize, variation (phenocrystic etc.), lamination, lineation, jointing.

Field 3 : Mineralogy (brief), using abbreviations where possible (see Appendix 1). Essential minerals first, phenocrystic species in square [] brackets, then minor minerals second in round () brackets.

Field 4 : Optional information e.g. relationship to other samples in project.

Formation

Usually two fields, only the first being searchable, separated by semi-colons, as follows :

Field 1 : Formal name where available to describe the rock unit, preferably at Formation level (max 80 characters), to be used for data search purposes. For New Zealand rocks the Stratigraphic Index of the Geology of New Zealand (Suggate 1978) is a very useful start (see Appendix 3).

Field 2 : Optional, details relating rock dated to a geological context e.g. position in sequence, relationship to other rocks.

Location

Usually two fields, with the first being searchable, separated by semi-colons, as follows :

Fields 1 : Smallest formally named geographic feature first (see New Zealand and Antarctic Gazetteers of Placenames) appropriate to the location, e.g. Mt Christina; then other appropriate major formal geographic names e.g. Darran Mountains, Fiordland.

Field 2 : Minor details appropriate to precise location (e.g. bluffs on west ridge at 750 m altitude).

Grid Reference

Three fields, all searchable, of which at least one must be completed.

Field 1 : New Zealand Metric Grid Reference (NZMS260)

Field 2 : New Zealand Imperial Grid Reference (NZMS1)

Field 3 : Latitude and Longitude (preferably given as °E/W °N/S with decimal parts of a degree.

In New Zealand, preference will be given to metric grid references but all three fields will be computed later and included in the database. Elsewhere, latitude and longitude should be given.

Figure 2

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Geochronology project : Sample details

R

Rock description (mineralogy and texture): Granodiorite; medium cryst,
dark grey, equigranular; qtz-pl-bi ± kf; dark. slightly finer variant of
granite about 15 m from contact with Greenland Grou. greywackes.

Formation : Barrytown Granite (informal name).

Location : Barrytown; Hwy 6 bridge over Granite Creek.

Grid ref*: S37/843133

Contributor's name : A.J. Tulloch

Sample no. and Organisation : 85/226 (two separate pieces) NZGS

Date : 1/3/87

INS action : _____

* Grid ref: use NZMS 260 Metric (1:50,000) or NZMS1 Imperial (1:63,360) or Latitude/longitude.

Contributor, Contributor No., Organisation

Three fields, all searchable (each max 15 characters) separated by semi-colons, as follows :

Field 1 : Contributor's surname and initials, or full initials
 Field 2 : Contributor's sample or field or laboratory number
 Field 3 : Contributor's affiliation or organisation as appropriate.

The main ones are abbreviated :

AU = Auckland University
 WU = Waikato University
 MU = Massey University
 VUW = Victoria University
 CU = Canterbury University
 OU = Otago University
 NZGS = NZ Geological Survey
 INS = Institute of Nuclear Sciences
 GD = Geophysics Division

Date

Date that samples were submitted by contributor

INS Action

INS use only. Date received and details of rock preparation and mineral separation to be attempted.

Information on sample forms is then transferred to the main INS database on the Gracefield VAX computer. This is integrated with the companion K-Ar and Rb-Sr analytical databases and in a slightly reformatted tabular version they will provide the basis for a comprehensive catalogue of NZ age data. This may be published separately or accessed for data search purposes at a later date.

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Appendix 1: Suggested abbreviations for common minerals

actinolite	act
albite	ab
amphibole	amph
andesine	and
anorthite	an
apatite	ap
augite	aug
biotite	bi
bytownite	by
calcite	cc
carbonate	carb
clinopyroxene	cpx
chlorite	chlor
crystalite	cris
epidote	ep
feldspar	fs
garnet	gnt
glauconite	gl
hornblende	hb
hypersthene	hy
illite	illite
ilmenite	ilm
Kyanite	ky
labradorite	lab
lithics	lith
magnetite	mt
microcline	mn
monazite	mon
muscovite	mu
oligoclase	olig
olivine	ol
orthoclase	or
orthopyroxene	opx
plagioclase	pl
prehnite	preh
pumpellyite	pump
pyroxene	px
quartz	qz
sanidine	san
sericite	ser
sillimanite	sill
sphene (titanite)	sph
tremolite	trem
zeolite	zeol
zircon	zr

Appendix 2 : Suggested rock names (from Reed 1964) and prefixes and suffixes

Volcanic

Oversaturated	rhyolite, rhyodacite, dacite, ignimbrite, pumice, obsidian, pitchstone, -pyroclastic, -ash, tephra, -tuff, -breccia
Peralkaline	peralkaline-rhyolite, -trachyte etc, pantellerite, comendite, palagonite
Saturated intermediate	trachyte, trachyandesite, andesite, basaltic andesite, -pyroclastic, -tuff, -breccia
Saturated basic	basalt, dolerite, trachybasalt, tholeiite, ankaramite, picrite, tachylite, -pyroclastic, -tuff, -breccia
Undersaturated	basanite, phonolite, tinguaita, mugearite, leucite, limburgite, nephelinite, -pyroclastic, -tuff, -breccia
Spilitic	spilitic, keratophyre
Lamprophyric	lamprophyre, minette, spessartite, camptonite, monchiquite

Plutonic

Oversaturated	granite, alkali granite, adamellite, granodiorite, aplite, granophyre, -pegmatite, -greisen
Peralkaline-	
Saturated intermediate	syenite, monzonite, diorite
Saturated basic	gabbro, norite, anorthosite
Undersaturated	nepheline-syenite, -monzonite etc, theralite, teschenite
Ultramafic	peridotite, dunite, pyroxenite, hornblende, serpentinite, kimberlite
Metasomatic	greisen
Segregations	xenolith, nodules, vein

Contact Metamorphic

Hornfelsic	hornfels, pelitic-, quartzfeldspathic-, quartz-, calc-silicate-, basic-, cordierite-, andalusite-, sillimanite-, corundum-, chloritoid-, etc.
Calcareous	marble, skarn

Regional Metamorphic

Schistose	schist, phyllite, slate, greenschist, quartzofeldspathic-, quartz-, mica-, hornblende-, garnet-, glaucophane-, etc.
Gneissose etc	gneiss, migmatite, granulite, amphibolite, eclogite, charnockite
Calcareous	calc-schist, marble

Dynamic metamorphic

Cataclastic-	mylonite, phyllonite, cataclastite, pseudotachylite
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Sedimentary

Argillaceous	udstone, siltstone, shale, argillite, loess
Arenaceous	sandstone, grit, graywacke, greensand, tuff
Rudaceous	conglomerate, breccia
Siliceous	chert, diatomite
Calcareous	limestone, dolomite, travertine
Ferruginous-	ironstone, manganese-
Phosphatic-	phosphorite
Carbonaceous	coal, wood
Fossil	shell

Appendix 3:

Some New Zealand Formation (and related rock unit) names from the Stratigraphic Index of the Geology of New Zealand (Suggate 1978)			
Abbotsford-Mst.	Brunswick-Alluv.	Emerald-Gravel	Hohoni-glac.-adv.
Aberfoyle-Zst.	Brunswick-Beach-Sediments	Enslin-Stage	Hokoni-Assemblage
Addison-Fm	Brunswick-Dunesand	Enys-Fm	Holme-Station-Lst.
Anahu-Sst.	Brunswick-Fm	Ess-Fm	Houli-Sands
Ahuhu-Subgroup	DYrunswick-Pebble-Sand	Ess-Creek-Fm	Horoke-Basalts
Akaroa-Gp	Brunswick-Terrace	Etalian-Stage	Horokira-Fm
Akaroa-Volc.	Brydone-Terrace	Etheiton-Cgl.	Houhora-Fm
Alabas'er-Gp	Bryneira-Gp	Eyre-Sst.	Houhora-Keratophyre
Albany-Cgl.	Buchia-hochstetteri-plicata-zones	Fall-Cgl.	Houhora-Volc.
Albert-Town-glac.-adv.	Buchia-aff.-misolita-zone	False-Islet-Fm	Houma-Lst.
Albion-Fm	Burnand-Alluv.	Fernwell-Fm	Houma-Sst.
Alexandra-Volc.	Burnham-Fm	Ferndale-Gp	Haka-Fm
Alma-Gp	Burnside-Mst.	Ferry-Sst.	Hamboldt-Gp
Alpine-Assemblage	Burnt-Creek-Fm	Fiordland-Complex	Immp-Ridge-Fm
'Alpine-facies'	Burrell-Fm-ashes	First-main-eruptive-phase	Immphryst-Cgl.
Alpine-schist	Butlers-Shell-Cgl.	'Flag-Hill'-Series'	'Imua-facies'
Altonian-Stage	Butt-Fm	Flagstaff-Phonolite	Hurival-Fm
Amberley-Lst.	Cable-Granodiorite	Flora-Fm	Hurival-Gp
Amokura-Fm	Calceonian-Fm	Flowerspot-Lst.	Huri-mi-plant-beds
Amuri-Lst.	Callaghan-Zst.	Flowers-Fm	Hurupi-Fm
Anatoki-Fm	Callaghans-Greensand	Ford-Zst.	Hutchingsian-Stage
Anchorage-Granite	Cameron-Granodiorite	Fordell-Tuff	Hutt-Alluv.
Anglem-Complex	Camp-Cove-Cgl.	Foreshore-Fm	Idoceras-Zone
Anglem-Gp	Camp-Hill-Fm	Foreshore-Gp	Imungia-Fm
Anita-Ultramafics	Canaan-Granodiorite	Forest-Hill-Lst.	Inglewood-Fm
Annear-Sst.-Fm	Canington-Gravel	Foxton-Dunesand	Inglewood-Lahars
Aorangi-Mine-Fm	Copies-Gp	Franklin-Basalt	Inia-Gravel
Aorere-Gp	Captain-King's-Shellbed	Franklin-Cgl.	Initial-Eruptive-Phase
Aorere-Series	Carter-Zst.-member	Frankton-Sub-gp	Iron-Creek-Greensand
Aotea-Sst.	Cascade-Cgl.	Fraser-Fm	Ironwood-Fm
Ayatu-Gp	Castlecliff-Shellbed	Garden-Cove-Fm	Island-Sst.
Aramoho-Pumice-Alluv.	Castlecliffian-Stage	Garden-Point-Epidiorite	Iwi-Kahi-Gp
Aranuian-Stage	Castlemainian-Stage	Garston-Fm	Jackson-Head-Lst.
Aratauran-Stage	Caversham-Sst.	Gebbies-Pass-Volc.	Jay-Breccias
Arnold-Series	Cement-Hill-Beach-Gravel	Gebbies-Rhyolite	Jay-Coal-Measures
Arnott-Volc.	Centre-Burn-Fm	Gedinnian-Stage	Jay-Fm
Arpmanan-Stage	Charleston-Metamorphic-Gp	Gee-Greensand	Jerusalem-Sst.
Arthur-Marble	Charteris-Eay-Sst.	Georgetown-Fm	Jones-Fm
Arthurton-Gp	Chatham-Schist	Geraldine-basalt	Kaawa-Fm
Atene-Sst.	Chatton-Marine-Fm	Gisborne-Stage	Kaawa-Sst.
Atherree Fm	Chatton-Sand-Member	Gladstone-Fm	Kaawa-Shellbed
Athol-Fm	Chatton-Series	Glen-Afton-Claystone	Kaharoa-Ash
Athol-Moraines	Chewtonian-Stage	Glen-Massey-Fm	Kahutara-Fm
Auckland-Basalts	Christchurch-Fm	Glen-Massey-Sst.	Kahutara-Tuff
Auckland-Domains-Basaltite	Clarence-Series	Glenburn-Fm	Kaitaka-Fm
Aulacosiphinctoides-zone	Clarendon-Sand	Glendale-Lst.	Kaitaka-Mst.
Aviemore-Fm	Clent-Hills-Fm	Glenham-Porphry	Kaitaka-Zst.
Avoca-glac.-adv.	Cliffon-Lst.	Glenhope-Beds	Kaitaka-Stage
Awakino-Lst.	Cliffonian-Stage	Glenhope-Fm	Kaitaka-I-Beach-Sand
Awamoa-Stage	Cliff-Alluv.	Glenzie-Fm	Kaitaka-II-Beach-Sediments
Awatea-Lst.	Clinton-Series	Goat-Fm	Kaitaka-III-Beach-Sediments
Awatea-Lignite	Cluden-Fm	Golden-Bay-Gp	Kaitaka-Fm
Awatere-Gp	Clyde-glac.-adv.	Golden-Bay-Schist	Kaitaka-I-Fm
Awatuna-Fm	Clyde-Fm	Goldlight-Mst.	Kaitaka-II-Fm
Awheia-Fm	Clyde-Moraine	Good-Creek-Fm	Kaitaka-III-Fm
Awheiti-Fm	Coal-measures-Cretaceous, Otago	Gore-Lignite-Measures	Kaitaka-Terraces
Awitu-Fm	Coal-Point-Fm	Gore-Piedmont-Gravel	Kaitaka-I-Terrace
Awitu-Sands	Cobb-Intrusives	Gore-Series	Kaitaka-II-Terrace
'Axial-facies'	Cobden-Lst.	Gorge-Cgl.	Kaitaka-III-Terrace
Balfour-Series	Cockeye-Fm	Graham-Peridotite	Kaitiaki-Stage
Balloom-Fm	Coleman-Cgl.	Grampian-Fm	Kaitiaki-Fm
Balmoral-Fm	Colliers-Coal-Measures	Graptolite-Zones, -Ordovician, -M.Z.	Kaitiaki-Gp
Balmoral-glac.-adv.	Complex-Point-Fm	Great-Harborough-Cgl.	Kaitiaki-Gp
Barrier-Fm	Complex-Point-Schist	Greatford-Alluv.	Kaitiaki-Zst.
Bastion-'Series'	Conical-Hills-Complex	Green-Hills-Fm	Kaitiaki-Shell-Grit
Baton-Cgl.	Conical-Hills-Volc.	Green-Island-Loose-Sst.	Kaitiaki-Greywacke
Baton-Fm	Constant-Gneiss	Greenland-Gp	Kaitiaki-Schist
Baton-River-Gp	Cookson-Volc.	Greenland-Series	semi-schist
Bay-Schist	Coral-Bluff-Lst.	Greenstone-valley-ultramafic-volcanic	Kaitiaki-Pumice-Sand
Beaumont-Coal-Measures	Cossyrite-Phonolite	Greenwood-Fm	Kaitiaki-Zst.
Beehive-Epidiorite	Countess-Fm	Greta-Zst.	Kaitiaki-Zst.
Beeson's-Island-Volc.	Coverham-Gp	Greville-Fm	Kaitiaki-Gravel
Belmont-Alluv.	Coverlan-Stage	Grey-Mari	Kaitiaki-Alluv.
Ben-Ghau-Fm	Craigmore-Lst.	Grimm-Fm	Kaitiaki-III
Bendigo-Fm	Croisilles-Volc.	Groom-Creek-Fm	Kaka-Fm
Bendigoan-Stage	Cunaris-Gp	Gullford-Gravel	Kakahu-marble
Benmore-Bentonitic-Shale	Curio-Bay-plant-beds	Haast-Schist-Gp	Kakahu-Mineral-Breccia
Berlins-Porphry	Cuvier-Plutonics	Haast-Schist-Zone	Kakapo-Granite
Birch-Hill-glac.-adv.	Dannevirke-Alluv.	Haastina-Haastiana-Assemblage-Zone	Kamahi-Terrace-Gravel
Birch-Hill-Moraines	Dansoy-Gravel	Hadfield-Fanglomerate	Kamo-Coal-Measures
Birley-Andesite	Darran-Diorite	Hales-Knob-Quartzite	Kamoharui-Fm
Black-Grit	Darrivillian-Stage	Hakurimatua-Fm	Kanlere-Series
Black-Hills-Volcanic-Complex	Deamans-Creek-Gp	Halcombe-Cgls.	Kapanga-Propylite
Black-Marls	Deas-Cove-Granite	Hampden-Fm	Kapiti-Stage
Blackwater-glac.-adv.	Deborah-Volc.-Fm	Hampden-Fm	Kapiti-Fm
Blue-Bottom-Fm	Dee-Fm	Hapurangi-Rhyolite	Karaka-Zst.
Blue-Mountain-Lst.	Devil-River-Volc.	Hapuka-Fm	Karame-Batholith
Bluecliffs-Silt	Diamond-Harbour-Gp	Harper-Hills-Volc.	Karame-Granite
Bluff-Complex	Donnelly-Cgl.	Haumuri-Stage	Karapiro-Fm
Bluss-Sst.	Douglas-Fm	Hauriri-Cgl.	Karapiro-Fm
Boatlanding-Bay-Fm	Dwelling-Bay-Lst.-Member	Hauriri-Gp	Kathryn-Fm
Bolindian-Stage	Dun-Mountain-Ultramafics	Hauraki-Clay	Kathi-Fm
Bombay-Basalt	Dunedin-Volcanic-Complex	Hautapu-Lst.	Kauru-Fm
Bortonian-Stage	Dunhill-Coal-Measures	Hautapu-Valley-Agglomerate	Kaweka-Greywacke
Botanical-Hill-Amm	Dunhill-Fm	Hautapu-Shellbed	Kawhia-Series
Bothwell-Sands	Dunphail-Zst.	Hautapu-Stage	Kekerengu-Fm
Bourne-Cgl.	Dunrobin-Fm	Hautapu-Substage	Kekerengu-Gp
Bourne-Fm	Dunrobin-Stage	Hautapu-Andesite	Kerikeri-Volc.-Gp
Boundary-Island-Granite	Dusky-Fm	Hawa-glac.-adv.	Kimolton-Tuff
Bradshaw-Fm	Dusky-Sound-Series	Hawera-Series	Kingston-Fm
Bradshaw-gneiss	Earl-Fm	Hawks-Crag-Breccia	Kinoheku-Belmontite-Bed
Braxton-Fm	East-Coast-Volc.Fm	Hawkei-Fm	Kinoheku-Fm
Braxtonian-Stage	Eastern-Bush-Terrace	Headland-Cgl.	Kinoheku-Zst.
Brighton-Lst.	Eastonian-Stage	Hekepe-Zst.	Kirihi-Gp
Brook-Street-Volc.	Echinus-Granite	Henley-Breccia	Kiwitahi-Sst.
Brooklyn-Diorite	Eglinton-Bluffs-Keratophyre	Herangi-Series	Kiwitahi-Volc.
Bruce-Gravel	Eglinton-Volc.	Herbert-Fm	Knapdale-Terrace
Brunner-Beds	Edmont-Terrace	Heretaunyan-Stage	Knobs-Porphryite
Brunner-Coal-Measures	Elaine-Bay-Oppel-Zone	Herring-Fm	Koheroa-Zst.
Brunner-Fm	Elgood-Lst.	Heterian-Stage	Kokoamu-Greensand
	Elliotvale-Fm	Hetherington-Cgl.	Kopuldroa-Dunesand
	Ellis-Fm	Hilton-Lst.	Korangan-Stage
	Ellis-Quartzite	Himalangi-Gp	Korotora-Marine-Gravel
	Elsdun-Fm	Hinahine-Fm	Korotora-Block-Sand
	Eltham-Fm	Hinuera-Fm	Kosmatia-Zone
	Eltham-Lahars	Hogburn-Fm	Koufotahi-Sst.

- Kowai-Gravel
- Kowhai-Point-Zst.
- Kumara-1-glac.-adv.
- Kumara-2-glac.-adv.
- Kumara-3-glac.-adv.
- Kumera-Fm
- Kupe-Fm
- Kuranui-Lst.
- Kuriwao-Gp
- Kuruv-Fm
- Kyeburn-Beds
- Kyeburn-Fm
- Lancefieldian-Stage
- Landguard-Fm
- Landguard-Sand
- London-Series
- Larps-Porphyrite
- Lee-River-Gp
- Leith-Valley-andesite
- trachyandesite
- Lepperton-Fm
- Lepperton-Lehars
- Leslie-Fm
- Letham-Fm
- Lighthouse-Andesite
- Lillburnian-Stage
- Linds-glac.-adv.
- Little-Ben-Sst.
- Little-Paparoa-Silt
- Little-Twin-Argillite
- Little-Twin-Fm
- Little-Twin-Splite
- Livingstone-Volc.
- Lochar-Fm
- Lockett-Cgl.
- Logans-Point-Phonolite
- Loisels-Ash
- Long-Reef-Breccia
- Long-Sound-Fm
- Long-Sound-Series
- Longford-Fm
- Longwood-Complex
- Longwood-Intrusives
- Lookout-Fm
- Lookout-Volc.
- Loopline-Fm
- Lower
- Awakino-Lst.
- Braxtonian-Stage
- Castlecliff-Shellbed
- Etalian-Stage
- Kalini-Zst.
- Kumera-Fm
- Manuherikia-Fm
- Maxwell-Fm
- Mokau-Sst.
- Okahu-Zst.
- Okawa-Gp
- Otapirian-Stage
- Paparoa-Gp
- Reefton-Quartzite
- Temakan-Stage
- Teredo-Stage
- Urvergan-Stage
- Westmere-Zst.
- Luggate-glac.-adv.
- Luggate-Fm
- Lytelton-Gp
- Lytelton-Volc.
- McDonald-Lst.
- Mackay-Intrusives
- McNaught-Shellbed-Member
- McPherson-Cove-Cgl.
- McQueens-Andesite
- Maheno-Marl
- Mahoevui-Fm
- Mahoevui-Gp
- Mahoevui-Mst.
- Mahurangi-Lst.
- Maitahi-Fm
- Maitahi-Lehars
- Maitai-Gp
- Maitai-Lst.
- Makaroro-Gp
- Makarawan-Stage
- Makirikiri-Tuff
- Mako-Clay
- Makokako-Sand
- Makokoff-Hill-Gp
- Makotarian-Stage
- Mania-Hill-Gp
- Mania-Hill-'Series'
- Manapouri-System
- Manapoua-Series
- Manapoua-Zst.
- Manakahi-Gp
- Manakotuku-Zst.
- Manamahu-Concretionary-Member
- Manamahu-Shellbed
- Manapoua-Stage
- Manapoua-Mst.
- Manapoua-Stage
- Manapoua-Shell-Cgl.
- Manapanian
- Manapoua-Sst.
- Manapoua-Stage
- Manapoua-Sst.
- Manapoua-Measures
- Manapoua-Fm
- Manapoua-Sst.
- Manapoua-Fm
- Manapoua-'Series'
- Manamahu-Mst.
- Manyles-Fm
- Manunui-Lignite-Beds
- Manutoto-Series
- Manuherikia-Fm
- Manuherikia-'Series'
- Manuka-Fm
- Manukau-Breccia
- Manurewa-Fm
- Maori-Bottom-Fm
- Maori-Bottom-Series
- Mapihi-Fm
- Mapihi-Zst.
- Marahau-Substage
- Marakura-Fm
- Mararua-Fm
- Marlborough-Schist
- Marokopa-Fm
- Martins-Bay-Fm
- Marton-Alluv.
- Maruia-Fm
- Maryville-Coal-Measures
- Mata-Series
- Matahiwi-Sst.
- Matakoia-Volc.
- Matanginiui-Lst.
- Mataroa-Concretionary-Sst.
- Mataura-Falls-Plant-Beds
- Mataura-Gp
- Mataura-'Series'
- Mataura-Terrace
- Matemateanga-Fm
- Matenga-Fanglomerate
- Matira-Zst.
- Matiri-Fm
- Maungarei-Dacites
- Mavora-Moraine
- Maxwell-Fm
- Maxwell-Gp
- Mead-Hill-Flint
- Medway-Fm
- Mercer-Sst.
- Merton-Terrace
- Middle-Maxwell-Fm
- Middle-Manuherikia-Fm
- Middle-Paparoa-Gp
- Milburn-Lst.
- Milford-Fm
- Minden-Rhyolites
- Mirza-Fm
- Mitima-Sands
- Moana-Fm
- Moatao-Cgl.
- Moehau-Fm
- Moehau-'Series'
- Moeraki-Fm
- Mohakaiti-Fm
- Mohakaiti-Gp
- Mohakaiti-Tuff
- Mokau-Fm
- Mokau-Gp
- Mokau-Sst.
- Mokini-Fm
- Mokoiwi-Mst.
- Mokolian-Stage
- Momoe-a-toa-Tuff
- Morere-Mst.
- Moryan-Coal-Measures-&Volcans
- Moryan-Fm
- Morley-Coal-Measures
- 'Morrinsville-Facies'
- Morven-Fm
- Mossburn-Fm
- Mosston-Sand
- Motuan-Stage
- Motuitui-Dunesand
- Mount-Arthur-Gp
- Mout-Arthur-Series
- Mt-Brown-Fm
- Mt-Camel-Fm
- Mt-Camel-Volc.
- Mt-Curi-Tephra
- Mt-Herbert-Lavas
- Mt-John-Fm
- Mt-John-glac.-adv.
- Mt-Messenger-Fm
- Mt-Messenger-Sst.
- Mt-Misery-Volc.
- Mt-Olympus-pluton
- Mt-Potts-plant-beds
- Mt-Prospect-Gravels
- Mt-Solitary-Fm
- Mt-Solitary-gneiss
- Mt-Somers-Volc.
- Moutere-Gravel
- Murray-Gravel
- Munopoko-Greensand
- Munopoko-Lst.
- Murchison-Granite
- Murikhu-Supergroup
- Naseby-Greensand
- Nathan-Sst.-Member
- New-Brighton-Cgl.
- New-Plymouth-Fm
- New-Plymouth-Lehars
- Newell-Fm-ashes
- Newcastle-Gp
- Ngohe-Volc.
- Ngarino-Beach-Sediments
- Ngarino-Fm
- Ngarino-Terrace
- Nyatatura-Nasalt
- Nyatterian-Stage
- Nyatatura-Volc.
- Nyataturu-Claystone
- Nidd-Fm
- Nightcaps-Gp
- Nile-Fm
- Nine-Mile-Fm
- North-Cape-Fm
- North-Etal-Gp
- North-Range-Gp
- North-Tern-Volc.
- Nukumarua-Brown-Sand
- Nukumarua-Fm
- Nukumarua-Gp
- Nukumarua-Lst.
- Nukumarua-s.s.-and-s.l.-usage
- Nukumarua-Stage
- Nurse-Fm
- Oamari-Diatomite
- Ocean-View-Fm
- Ohai-Gp
- coal-measures
- Ohakea-Alluv.
- Ohakea-Terrace
- Ohau-Stage
- Ohautira-Cgl.
- Ohika-Beds
- Ohika-Fm
- Ohineruru-Fm
- Ohingaiti-Sand
- Ohui-Ash
- Ohuka-Carbonaceous-Sst.
- Ohau-Fm
- Oharito-Fm
- Okahu-Gp
- Okahu-Shell-Grit
- Okahu-Zst.
- Okahu-Substage
- Okawa-Gp
- Old-Man-Bottom
- Old-Man-Gravel
- Old-Man-Group
- Olympus-Granite
- Omaha-Andesite
- Omahu-Shellbed
- Omahu-Fm
- Omahu-Mst.
- Omahu-Granite
- Onawe-Plutonics
- Onetake-Schist
- Onetahi-Chaos-Breccia
- Onetahi-Fm
- Onoua-Lst.
- Opahi-Gp
- Opapak-Sst.
- Opotian-Stage
- Opunake-Fm
- Opunake-Lehars
- Opunake-Stadial
- Orahiri-Lst.
- Oraka-Sst.
- Orangihao-Andesite
- Orakea-Mst.
- Ordovician-Stage, -N.Z.-(cf.-Aust.)
- Orupuki-Terrace
- Oronian-Stage
- Ormond-Fm
- Ostrea-Bed
- Otago-Schist-belt
- Otago-Volc.-Complex
- Otaihuhu-Shellbed
- Otaia-Greensand
- Otaian-Stage
- Otaihanga-Quartzite
- Otaio-Gorge-Sst.
- Otaki-Fm
- Otaki-Dunesand
- Otaki-Sst.
- Otama-Complex
- Otama-Intrusives
- Otama-Terrace
- Otamitan-Stage
- Otanomomo-Complex
- Otapirian-Stage
- Otaranga-glac.-adv.
- Otau-Fm
- Otau-Gp
- Oteakiki-Lst.
- Oteke-Series
- Oteku-Fm
- Otepu-Greensand
- Otira-Glacial
- Otiran-Moraines
- Otiran-Stage
- Otorohanga-Lst.
- Otokaka-Zst.
- Otokaka-'St.-Tongue
- Otterson-Fm
- Oturi-Zst.
- Oturi-Interglacial
- Oturi-Stage
- Ouse-Fm
- Ouse-Zst.
- Owaka-River-plant-beds
- Owai-Fm
- Owhiro-Subgroup
- Owhiro-Zst.
- Paparoa-Ignimbrite
- Pakamau-Ignimbrite
- Pakamau-coal-measures
- Pakamau-Gp
- Pakihuru-Pumice
- Pakihuru-Gravel
- Pakihuru-Andesite
- Papakura-Fm
- Papakura-Lst.
- Papamoa-Ignimbrite
- Paparangi-Fm
- Paparangi-Gp
- Paparangi-Sst.
- Paparoa-Batholith
- Paparoa-Beds
- Paparoa-Coal-Measure-Gp
- Paparoa-Granite
- Paparoa-Gp
- Parabolical-zone
- Parahaki-Volc.-Gp
- Parapara-Gp
- Parata-Gravel
- Paeroa-Series
- Parihauhu-Shellbed
- Parikawa-Fm
- Paringa-Fm
- Paritu-Tonalite
- Parihakaoho-Slate-Member
- Park-Intrusives
- Parrell-Grit
- Patea-Dunesand
- Paterson-Fm
- Paterson-Gp
- Paton-Fm
- Patriarch-Fm
- Patukui-Volc.
- Patukui-Fm
- Pebble-Hill-Gravel
- Peel-Fm
- Pegasus-Fm
- Pegasus-Gp
- Peiorus-Gp
- Penfryn-Rock-Intrusives
- Peppin-Gp
- Pepper-Shell-Sand
- Petane-'Series'
- Petane-Marine-Sand
- Pikihina-Schist
- Pine-Bus-Fm
- Pinnacle-Sand
- Pipio-serpentine
- Pipitiki-Sst.
- Piripauan-Stage
- Pitt-Gp
- Platform-Gneiss
- Pleuraya-milleformis-Assemblage-Zone
- Pohui-Series
- Pokapu-(Mahurangi)-Lst.
- Pokororo-Pyroxenite
- Pomaka-Estuarine-Bed
- Pomona-Granite
- Ponowhakatiki-Zst.
- Poringan-Stage
- Porirua-Fm
- Porirua-Gp
- Porirua-Al'uv.
- Porirua-Fm
- Porirua-Glacial
- Porirua-Stage
- Port-Elizabeth-Beds
- Port-Elizabeth-Mst.
- Porter-Gp
- Potaka-Pumice
- Pouakai-Gp
- Pouakai-Volc.
- Pouaiter-glac.-adv.
- Pounamu-Fm
- Pounamu-'Series'
- Pounamu-Fm
- Preservation-Fm
- Preservation-Inlet-Series
- Princess-Fm
- Productus-Creek-Gp
- Puaruan-Stage
- Puaruan-Stage, 'A'-and-'B'
- Puu-Creek-Varved-Silt
- Pukekohe-Dacites
- Pukekohe-Shell-Sand
- Pukimiro-Sst.
- Pukimiro-Shale
- Puketapu-Fm
- Puketaka-Fm
- Punakitere-Sst.
- Puponga-Fm
- Pupu-Cgl.-Member
- Purakaiti-Fm
- Puruhau-Stage
- Purupuru-Tuff
- Putehi-Rhyolites
- Putataka-'Series'
- Putataka-Supergroup
- Putau-Zst.
- Puti-Zst.
- Putiki-Shellbed
- Putikian-Substage
- Puysegur-Fm
- Qail-Island-Basalts
- Quartzite-Brunner-Coal-Measures
- Rai-Fm
- Rai-Sst.
- Rakehua-Granite
- Rameka-Diorite
- Rameka-Intrusives
- Ramsey-Gravel
- Rangitike-Ignimbrite
- Rangitike-Ignimbrite
- Rangitike-Serpence
- Rangitika-Fm
- Rangitika-Marble
- Rangitike-Volc.-ash
- Rapanui-Beach-Sediments
- Rapanui-Dunesand
- Rapanui-Fm
- Rapanui-Lignite
- Rapanui-Marine-Sand
- Rapanui-Terrace

