DOCUMENT RESUME

ED 236 032 SE 043 313

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TITLE Mountains. Science Education Research Unit. Working Paper No. 202.
INSTITUTION Waikato Univ., Hamilton (New Zealand).
PUB DATE Mar 82
NOTE 34p.; For related documents, see ED 226 976, ED 229 442, ED 230 594, ED 235 011-030, SE 043 285-302, and SE 043 305-315.
AVAILABLE FROM University of Waikato, Science Education Research Unit, Hamilton, New Zealand.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Reports - Research/Technical (143)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Comprehension; *Concept Formation; *Curriculum Development; *Earth Science; Elementary School Science; Elementary Secondary Education; Interviews; Learning; Science Education; *Science Instruction; *Secondary School Science
IDENTIFIERS *Learning in Science Project; Mountains; *New Zealand; Science Education Research

ABSTRACT

The Learning in Science Project has adopted the view that science teaching might be improved if teachers can be given some appreciation of students' views of the world and the beliefs, expectations, and language that learners bring to new learning situations. This investigation compares and contrasts views that children and scientists have on landforms, particularly on two New Zealand mountains (Mounts Egmont and Cook). Individual interviews were conducted with 37 students during which they observed colored photographs of various, well-known New Zealand landforms and described what they saw. Questioning was then directed toward eliciting their ideas concerning processes behind the appearances of the two mountains. Sample responses are presented related to such questions as: What is a mountain? Is Mount Egmont a volcano? When did Mount Egmont appear? How do volcanoes develop? What is a range? How did Mount Cook develop? Responses indicate that children/adolescents hold views about the two mountains which are likely to be different from scientifically accepted ideas. For example, approximately 63 percent were not aware that Mount Egmont has the potential to erupt again. In addition, the majority of students had not attained an appreciation of plate tectonics, even at an elementary level of understanding. (JN)

SCIENCE EDUCATION RESEARCH UNIT

MOUNTAINS

University of Waikato
Hamilton, N.Z.

WORKING PAPER 202

The Science Education Research Unit at the University of Waikato emerged from the research activity generated by the original Learning in Science Project (1979-1982). The aim of the unit is to facilitate and encourage Science Education Research.

One of the most successful innovations of the Learning in Science Project was the production of working papers whereby research findings could be shared with practising teachers and curriculum developers. This present series of papers (the 200 series) continues that tradition for research undertaken by members of the Unit but which does not form part of the Learning in Science Project.

We would welcome comment or information related to the topic of this paper.

Roger Osborne

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MOUNTAINS

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March 1982

Working Paper 202

INTRODUCTION :

The Learning in Science Project (FREYBERG, OSBORNE and TASKER, 1980) has adopted the view that science teaching, at all levels, might be improved if teachers can be given some appreciation of students' views of the world and the beliefs, expectations and language that learners bring to the new learning situation. The emphasis throughout the L.I.S.Project has been in the probing of difficulties by means of small-scale, in-depth studies that can be related to science teaching. The majority of these investigations have been identified with the Forms 1 - 4 science programmes.

Many of the earlier in-depth studies from the L.I.S.Project have tended to concentrate on areas of biology (STEAD, 1980(a); STEAD, 1980(b)) physics (OSBORNE, 1980; STEAD and OSBORNE, 1980) and chemistry (HAPPS, 1980; SCHOLLUM, 1981). Research into students' concepts and understanding in areas within the earth sciences, has been undertaken (MOYLE, 1980; HAPPS, 1981(a)) and this paper continues to add to our understanding of teaching and learning problems in this area.

This investigation looks at the topic "landforms" and, in particular, focuses attention on two of New Zealand's better known mountains, i.e. Mount Egmont and Mount Cook. This paper considers these landforms whilst comparing and contrasting the views that children and adolescents hold, regarding these mountains, with the scientifically acceptable views. In this way, it is hoped that a satisfactory 'base-line' can be constructed so that later teaching can more readily modify students' existing knowledge.

The topic 'landforms' has been identified as an important teaching area, by practising earth scientists and secondary teachers, (see HAPPS, 1981(b)) and is included in sections 4 (level 4) and 8 (level 5) of the Science : Forms 1 - 4 Draft Syllabus. The relevant extracts from this syllabus are shown in Appendix A.

WHY STUDY MOUNTAINS?

New Zealand has experienced volcanic activity since the mid-Tertiary[1] period. This activity has been largely concentrated in the North Island, including Northland, Coromandel, Auckland, Taupo and Taranaki. In the South Island, volcanism has occurred in the Dunedin area and Banks Peninsula. Numerous volcanic landforms

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1. The glossary, in Appendix B, offers an explanation of those terms that are commonly used by the earth scientist.

are to be found in the North Island and, the concentration of a number of dormant and active centres, calls for an awareness and vigilance, in terms of selecting sites for human settlement and commercial activities.

Present day landforms, in the South Island, are dominated by activity along the Alpine Fault which extends from Lake Rotoroa, near the Marlborough Sounds in the North East, to Fiordland, in the South West. This fault, which has been displaced a distance of 480 km represents a geologically interesting feature within a landmass where two major lithospheric plates interact and form a common boundary.

THE EARTH SCIENTISTS' VIEW OF VOLCANISM AND MOUNTAIN BUILDING IN NEW ZEALAND

Prior to any consideration of the ideas and views that children and adolescents may have, concerning Mount Egmont and Mount Cook, it should prove useful and appropriate to look at the ways in which the earth scientist might regard those same two landforms.

(i) A common mechanism : It is now generally accepted that almost all volcanic activity, earthquakes and mountain building (collectively termed tectonic activity) is located close to plate margins. Where these plates interact, much of the present day geological activity is taking place. New Zealand is situated astride the boundary where two lithospheric plates meet. The theory of plate tectonics proposes that the earth's lithosphere is 'broken' into a number of large 'plates'. These plates range in size from several hundred to several thousand km across, moving at velocities of several cm per year. As the plates are in motion, so too are the continents. Plates are able to change both their size and shape with time, thus new plates can form as original ones break up or plates may be 'fused' together during collision. Some plates can disappear completely as one plate underrides another and, at times, the plates have become stationary.

(ii) Mount Egmont : This feature is a stratovolcano (significantly larger than Mount St Helens, in the U.S.A.) which has been built up, from alternating deposits of lava and ash. to a height of 2,518 metres.

Activity probably started at the Mount Egmont site about 70,000 years before present (B.P.) with a substantial cone having been developed by 35,000 years B.P.[2] At about this time a large eruption led to the collapse

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2. More detailed information, concerning the 'history' of Mount Egmont, Mount Cook and the plate tectonic theory, can be obtained from the list of further reading, at the end of this paper.

of the main cone, resulting in a massive mud and debris flow (lahar). This deposit covered an area of 200 km^2 to a depth of at least 30 metres and this kind of 'event' has taken place several times since. Four eruptions have occurred during the last 500 years with the most recent activity, from Mount Egmont, taking place in 1755. Future eruptions are highly likely, with the present main crater being the most probable site. Such an eruption would most likely be towards the west and there is ample evidence to show that large mud and debris flows have, in the past, reached Inglewood, Kapuni, Cape Egmont and Opunake.

The type of plate margin which is associated with volcanism in the North Island of New Zealand,[3] is destructive, i.e. at an ocean trench, two plates approach each other with one underriding the other. This process is represented in Figure 1.

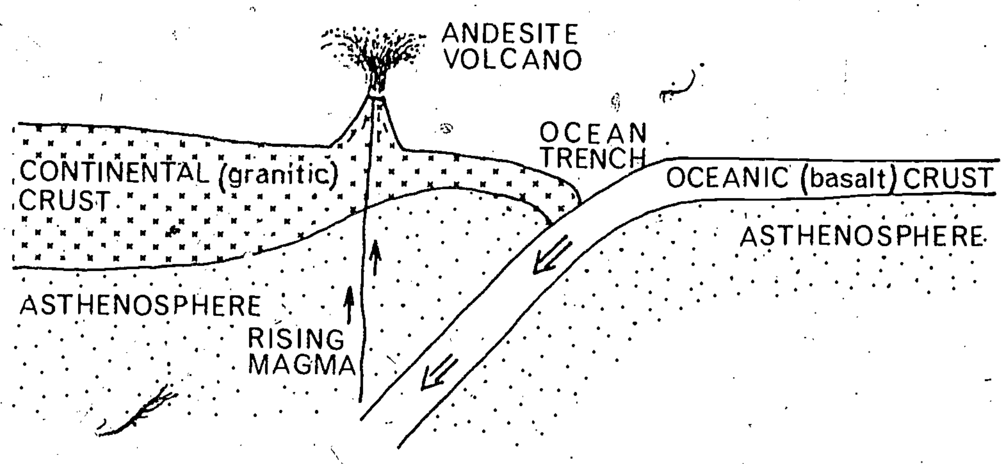

Fig. 1.

Partial melting of the downgoing plate, at a depth between 150 - 250 km, produces andesitic magmas which are rich in potassium, sodium and aluminium. The resulting composition of the magmas is due to a critical combination of pressure, temperature and water content. This less dense magma tends to rise toward the surface along subsurface fractures. Volcanoes such as Mount Egmont, are part of an 'andesitic line' which surrounds the Pacific Ocean Basin.

3. The model of volcanism via lithospheric plate interaction is simplistic for the purpose of clarity. There are a number of features, about this model, that may be revised with future research.

(iii) Mount Cook : The process of mountain building, in the form of upthrusted ranges, originates where crustal plates converge. Those active mountain ranges, where movement takes place today and earthquakes are experienced, lie within the Alpine and Circum - Pacific regions. The Himalayas offer an example of the effects of collision between two continental plates, yet most of the Earth's active mountain ranges are present where continental plates are in collision with oceanic crust.

The Alpine Fault represents the boundary between the Indian-Australian and the Pacific lithospheric plates. This major fault is called a trans-current fault, i.e. the fault movement (slip) is virtually in the direction that the fault lies. The total horizontal movement along the Alpine Fault has been 480 km, starting at the end of the Jurassic (130 million years B.P.),[4] with most of the movement having taken place during the last 60 million years.

Changes in plate boundary motion have resulted from shifts in the position of the pole of rotation of the Pacific Plate. This has led to a change from extension to oblique compression across the fault. Widespread faulting, folding and uplift of strata have resulted. Most earth scientists agree that 10 - 20 km of uplift has taken place on the Alpine Fault since the late Miocene (15 - 20 million years B.P.) and 5 km of uplift has been estimated for the last 5 million years.

The present uplift on the Southern Alps (including Mount Cook) has been estimated at more than 10 mm per year and this rate appears to keep pace with the forces of weathering and erosion. Without this continual compression and uplift, weathering and erosion processes would have reduced the Southern Alps to a region of gentle hills by now.

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4. The actual 'age' of movement along the Alpine Fault is still contentious and the data supplied here should be viewed as being indicative of approximate time-spans.

THE INVESTIGATION

Thirty-seven students (6 x F1, 5 x F2, 5 x F3, 6 x F4, 4 x F5, 6 x F6, 5 x F7)[5] from 7 co-educational schools, were interviewed on an individual basis. The students[6] were selected for interview by their teacher, who was asked to choose students of "average scientific ability".[7]

During the interviews, each of which lasted for approximately 30-45 minutes, students were shown coloured photographs (25 cm x 20 cm) of various well-known New Zealand landforms.

Students were asked to describe each landform, in turn, and to identify and 'locate' it if possible. Questioning was then directed toward eliciting the students ideas concerning the 'processes' behind the appearance of Mount Egmont and Mount Cook (only these two landforms will be discussed within the scope of this brief article). It was emphasised that what was required was the student's own ideas and viewpoints and that there would be little emphasis placed on whether responses were 'correct' or 'incorrect'. All interviews were maintained in an informal and non-threatening atmosphere throughout, with students being completely aware of the purpose behind the interview and the need for the use of audio-taping.

A number of cards were shown to students at the end of the discussion phase. A stimulus-word[8] was written on each card so that students were given the opportunity to provide information, in addition to that given when discussion centred around the photograph.

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5. F1 - F7 = Forms 1 - 7 (11 - 17 year olds)
6. A number of 6th and 7th form students were taking both geography and science subjects at the time of interview. Those students are coded with a (g).
7. It was considered, by the investigator, that students were generally average to slightly above average in most cases.
8. The words that were pertinent to this investigation were : VOLCANO, MOUNTAIN, RANGE.

WHAT IS A MOUNTAIN?

The term "mountain" was used by all 37 students in describing Mt. Egmont and students were then asked "What is a mountain - in your meaning of the word?"

Six students (2 x F1, 1 x F2, 2 x F3, 1 x F6) described a mountain as being "a large hill", whilst 5 students (2 xF1, 1 x F2, 1 x F3, 1 x F4) qualified this idea by stating that a mountain was "bigger than a hill". Other relative sizes of a mountain were noted:

> "something over a certain height." (302)
>
> " a huge bit of rock and sand that's bigger than anything else." (204)

Six students (1 x F2, 1 x F4, 3 x F5, 1 x F7) talked about a "big rocky structure", with three students (1 x F1, 1 x F3, 1 x F6) referring to "a big bump in the ground". Other variations of this were:

> "a risen piece of land." (405,504,601)
>
> "a large landform." (702)

The composition was noted in some definitions of a mountain:

> "a big clump of dirt." (203)
>
> "soil piled up." (403)
>
> "high rock made up of either molten rock or rock pushed up." (604)

Four students (3 x F4, 1 x F7) envisaged some relationship between a mountain and volcanoes:

> "to me it [mountain] means an extinct volcano." (705(g))
>
> C "a volcano - could be an active volcano or a dormant volcano - whatever."
>
> I "do you always see those two connected (mountain and volcano)?

C "I think so." (701)

reference was made to the age of mountains:

"they've probably always been there since the landmass was formed." (602)

Eleven students (4 x F1, 2 x F2, 2 x F3, 1 x F5, 2 x F7) included, within their definition, the fact that moun ins tend to have snow on them:

" a big hill with lots of ..... usually just got snow on it." (104)

"to me its a big piece of rock with jagged edges and snow on top." (501)

Some definitions contained on indication of the reasons why mountains developed:

"possibly formed by folding and faulting - otherwise could have been formed by volcanism". (605(g))

"created by stresses in the earth's crust." (704(g))

IS MT. EGMONT A VOLCANO?

Fifteen students (5 x F1, 3 x F7, 2 x F3, 1 x F4, 1 x F5, 2 x F6, 1 x F7) did not recognise Mt. Egmont as representing a volcano of any sort:

I "Is Mt. Egmont a volcano, do you think?"

H "No, I don't think so." (606)

Care had to be exercised, at this point in the interview, to establish what students understood by the term 'volcano' since the use of words such as 'extinct and 'dormant' may not be appreciated. Consequently, should a volcano not be seen to be currently eruptive, then students may fail to call it a volcano.

Twenty-two students (1 x F1, 2 x F2, 3 x F3, 5 x F4, 3 x F5, 4 x F6, 4 x F7) recognised the shape of Mt. Egmont to be that of a volcano:

I "Tell me more about the shape."

W "It's cone-shaped .. with a bit knocked off the top."

I "and does that tell you anything - with the cone-shape?"

W "It's probably a volcano." (502)

Eight students (1 x F2, 2 x F3, 2 x F4, 2 x F6, 1 x F7) were of the opinion that Mt. Egmont is extinct:

"It was probably a volcano once." (402,

I "You are talking about Egmont being extinct now?"

R "I think it is." (704(g))

The other 14 students (1 x F1, 1 x F2, 1 x F3, 3 x F4, 3 x F5, 2 x F6, 3 x F7) felt confident that Mt. Egmont was, or could be, a dormant volcano. This was stated explicitly:

"It's a sort of dormant volcano." (701)

WHEN DID MT. EGMONT APPEAR?

The origin of Mt. Egmont was probed in order to determine whether, or not, students generally appreciated that such landforms have not always been on the Earth's surface.

Twelve students (5 x F1, 1 x F2, 2 x F3, 2 x F4, 1 x F5. 1 x F6) felt that Mt. Egmont had always been there:

I "Have you got any ideas about how mountains might form - or have they always been there - do you think?"

S "I think they've always been there." (101)

I "How do you think that mountain (Egmont) got there - or has it always been there? What do you think?"

T " I think it would have always been there." (405)

Further questioning revealed that "always" meant (to the majority of the students) since the Earth was formed:

> I "How do you think that mountain (Egmont) got there - or has it always been there? What do you think?"
>
> K "It's always been there."
>
> I "and when you say 'always' - do you mean since the Earth was formed?"
>
> K "Yes." (303)

The term 'always' was occasionally used in a different context:

> I "How long is 'always' to you?"
>
> D "Ever since man stepped on the Earth."
>
> I "How long is that - do you think?"
>
> D "Millions of years." (305)

Four students (1 x F2, 2 x F4, 1 x F7) felt that Mt. Egmont had 'appeared' shortly after the Earth was formed:

> A "Way back in the beginning of time."
>
> I "When the Earth was formed?"
>
> A "No - a bit later." (204)

Difficulties were encountered in trying to imagine the sort of time-spans involved in such an estimate:

> "Nobody - I don't think anybody's got an estimate of that time anyway. They can't really see it." (703)

Other students attempted to estimate a time, during which Mt. Egmont evolved. These estimates ranged from 100 million years B.P. (1 x F2, 1 x F7); between 1 and 10 million years B.P. (1 x F3, 2 x F6) with a span of more recent dates:

> 300,000 years B.P. (1 x F6)
>
> 100,000 years B.P. (1 x F5, 1 x F6)
>
> Thousands of years (1 x F7)
>
> 2,000 years B.P. (1 x F2, 1 x F3)
>
> Hundreds of years (1 x F2)

The concepts of geologic time and major geologic events proved to be confusing ones, even to the more experienced students:

> "I don't know how far back the ice age is but it [Mt. Egmont] may have formed after that. It would be a lot colder and ... possibly dinosaurs. I'm not sure when they were around."
>
> (702)

HOW DO VOLCANOES DEVELOP?

The stimulus-word 'volcano' was shown and questions asked to find out if students could offer possible mechanisms for the development of volcanoes. Mt. Egmont was used as an example for those fifteen students who recognised this landform as being a volcano.

Twelve students (5 x F1, 1 x F2, 2 x F3, 2 x F4, 1 x F5, 1 x F6) considered present-day volcanoes to have "always been there", with no mechanisms considered. Other students did attempt to explain that some form of development was envisaged, although these explanations were generally vague:

> "It [volcano] forms when the Earth erupts." (504)

Some confusion was met over the term 'evolution':

> "It builds up by evolution."
>
> (205)

The meaning of the term 'evolution' was probed as it arose:

> A "Evolution."
>
> I "Tell me about that - evolution."
>
> A "It just grows through the years."
>
> (406)

One younger student (1 x F3) offered a sound explanation as to how a volcano is built up over time:

> "Well - when they start off they spurt out little bits of lava and it grows up higher and higher and higher and gradually, over the years, it gets to be that height. All the lava builds up."
>
> (305)

Some explanations were linked with earthquake activity:

"Earthquakes shake round the volcano and makes it erupt."

(402)

"It could have gotten there from - like - say the Earth moving - like an earthquake - being pushed up."

(604)

Reference was made to weaknesses in the Earth's crust:

"When there is a weak part - it opens up. The stuff underneath the Earth - you know - the magma and that - there is a lot of pressure on - it finds a weak part in the the Earth's surface and just comes up." (601)

"There's probably been a weakness in the earth's crust or something and the magma has come up - giving lava and then it's flowed down and hardened."

(704(g))

An idea of pressure building up, under the Earth's surface, was mentioned:

"The pressure of lava and steam and all that"

(106)

"The mountain has got all the pressure in the core of it. The pressure builds up and the core explodes out of it."

(502)

"It's due to pressures beneath the Earth finding a weak point and then erupting." (702)

Other explanations considered some form of activity along a fault-line:

"If it (Mt. Egmont) hasn't always been there - there's probably a fault-line and the Earth has just come up. The molten stuff from the middle of the Earth has just come up and it's bubbled over and just built a mountain up."

(401)

"It's got something to do with fault-lines." (404)

The view that heat has to get out of the Earth was mentioned:

"The material underneath the ground gets hot and it builds up, so it has to find somewhere to go - so it comes out the top." (501)

More idiosyncratic ideas were held by two of the older students:

I "So how was this (points to photograph of Mt. Egmont) actually formed - do you think?"

H "By washing of the tides, I suppose."

I "What was washed?

H "It was washed away here (points to base of mountain) from the flat ground."

(606)

C "I think that the Taranaki region is only there because of the volcano. It wouldn't be there if the volcano wasn't there - I think."

I "So what came first - do you think - the volcano or Taranaki?"

C "The volcano and then it all built up from eruptions and stuff coming out around the volcano."

(705(g))

Some hint at a theory involving plate tectonics was provided by nine students (1 x F1, 1 x F4, 1 x F5, 2 x F6, 4 x F7)

"Sometimes the plates of the Earth sort of push up and make the mountain sort of erupt and grow or get smaller."

(106)

This explanation was not significantly improved upon by older students who had heard of moving plates:

I "How are these plates related to volcanoes - do you think?

D "When they collide they make up mountains - from the middle of the Earth - all that stuff comes up."

I "What sort of stuff?

D "Lava and all that."

(503)

"Where the continents are all divided up - before they separated - where they come together - they grind together - it forces weaknesses in the Earth's crust and therefore the core is able to pressurise molten lava upwards."

(605(g))

"Areas where there are earthquakes - volcanoes or big mountains - they think there's plates which move around on the surface of the Earth and - where they run into each other - form earthquakes as they slip over or under, or pile up into mountains like the Himalayas."

(603)

C "It's something to do with the plates of the Earth sort of moving and the mountain could have been sort of pushed up."

I "Tell me more about these plates."

C "These plates are always moving. They were once joined together to form the great big continent of Pangea and they drifted apart. I'm not really sure how the mountain (Mt. Egmont) formed, but I think it might be something - when the two plates collide."

(701)

WHERE ARE VOLCANOES LIKELY TO BE FOUND?

This line of questioning was pursued following the stimulus-word 'volcano', e.g. "In what sort of places would you expect volcanoes to be found?". There was a wide spectrum of theories.

Eight students (4 x F1, 2 x F4, 2 x F5) were unable to suggest any possible location of other volcanoes, whilst five students (2 x F2, 3 x F3), used the term "special places" or stated that it "depends where they pop up", or "they appear where they appear."

I "Do they (volcanoes) just appear anywhere or in special places - or what?"

S "It depends where they pop up."

(301)

I "Do they (volcanoes) just sort of happen or - do they happen in special places or just anywhere at all - or what?"

J "It depends where the volcano is."

(304)

Other similar responses were given:

> "You find them in some places where a volcanic plateau is."
>
> (102)

Three students (1 x F1, 1 x F3, 1 x F5) felt that volcanoes could be found in all countries:

> I "What kind of place would you go - where would you go to find a volcano - is there an answer to that - or can they be found ...
>
> D "They can be found really anywhere."
>
> (305)

> I "Do you feel that you'd find volcanoes anywhere at all .. or ..
>
> M "Yes - I suppose you can."
>
> I "Any country at all?
>
> M "Yes."
>
> (504)

Three students (2 x F2, 1 x F3) considered the location of volcanoes to be climate dependent:

> I "What sort of places would you go to find volcanoes - anywhere at all - or special places - or what?
>
> R "Umm - mostly round warmer climates."
>
> I "Russia?
>
> R "No - that's getting a bit cold."
>
> (202)

> "They seem to be more towards the colder areas than up the warm areas."
>
> (302)

Two students (1 x F3, 1 x F4) were quite definite that mountains were always associated with volcanoes:

> I "Can you find volcanoes just anywhere or are they in special places?
>
> K "Mountains."
>
> (303)

Other idiosyncratic responses included specific regions where students considered volcanoes exist:

"Indonesia - and there's some volcano islands in the South Pacific and America - Mt. St. Helens."

(203)

"A lot of islands have them."

(606)

Fourteen students (3 x F4, 1 x F5, 5 x F6, 5 x F7) predicted that volcanoes would be found in association with specific geophysical phenomena. Four students (2 x F4, 2 x F6) referred to regions where fault-lines occur:

I "And where would you find these volcanoes anywhere at all?

D "On a fault-line."

I "Any fault-line - anywhere in the world?

D "Yes."

(602)

Two students (1 x F4, 1 x F6) stipulated that volcanoes would be found only in places where earthquakes are experienced:

"Pretty close to an earthquake belt."

(402)

One student (1 x F7) referred to the presence of volcanoes wherever areas of crustal weakness are located:

"They follow the arc of weakness."

(704(g))

Seven students (1 x F5, 2 x F6, 4 x F7) discussed the movement and interaction of crustal plates, associating these with volcanic activity:

I "And how are these plates related to volcanoes - do you think?

D "When they collide - they slowly make up mountains and sometimes - from the middle of the Earth - all that stuff comes up."

I "What sort of stuff?

D "Lava and all that."

(503)

"It's generally where you find most of the plates - where the plates come together."

(605(g))

I "And you find them (volcanoes) where - anywhere?"

C "No, not really anywhere - either where the two plates meet on fault lines or where there's a lot of Earth activity - like in geothermal places and stuff like that."

(704(g))

A CONSIDERATION OF MT. COOK

WHAT IS THE LANDFORM?

Only six students (2 x F4, 3 x F6, 1 x F7) recognised Mt. Cook from the photograph although, when the name of the landform was provided, 25 of the remaining 31 students (4 x F1, 4 x F2, 5 x F3, 2 x F4, 4 x F5, 2 x F6, 4 x F7) stated that they had heard of it. It is quite possible that the mountain might have been identified by more students had the photograph been taken from an alternative vantage point.

WHAT IS A RANGE?

The term 'range' was immediately used by 23 students (1 x F1, 2 x F2, 3 x F3, 5 x F4, 3 x F5, 4 x F6, 5 x F7) and all of these students were able to use the term in the correct context; following the question "What is a range - in your meaning of the word?"

A typical response was:

"A row of mountains such as the Southern Alps."

(603)

Thirteen students (5 x F1, 3 x F2, 2 x F3, 1 x F4, 2 x F6) had heard of the term 'range' but were unable to offer a geologically acceptable definition; rather they showed a tendency to provide everyday meanings of the word."

Ten of these students (3 x F1, 2 x F2, 2 x F3, 1 x F4, 2 x F6) talked about 'range' in terms of a large expanse of grazing land:

I "Have you heard of that (range)?"

C "Only in cowboy movies."

(205)

"It's a long lowland - a paddock - a feeding ground."

(406)

"In Texas they have ranges where they keep their steers - and that."

(602)

Three students (2 x F1, 1 x F2) offered alternative definitions for the term 'range':

"A range of different things." (105)

"A range of different shapes and sizes." (102)

"A big hillside." (201)

HOW DID MT COOK DEVELOP?

Fourteen students (2 x F1, 2 x F2, 2 x F3, 2 x F4, 2 x F5, 2 x F6, 2 x F7) felt confident that Mt Cook was, or still is, a volcano:

I "Have we got any volcanism there (Mt Cook) do you think?

C "Yes, we would have but I think the plug has sealed - so to speak." (703)

Questions were directed towards the identification of alternative theories concerning the formation of Mt Cook. A variety of explanations were forthcoming. Ten students (3 x F1, 2 x F2, 5 x F4) considered that Mt Cook has always been as it is today:

"It could have been there all the time." (404)

The meaning of "all the time" or "always" was probed, as these expressions arose:

A "It might have just been there."

I "Always been there?

A "Yes probably."

I "Now when you say "always been there" - how long is that? forever or ......"

A "Since time began." (406)

The difference between a landform being described as a volcano, or just a mountain, was often linked with its shape and/or isolation:

I "How would you describe this (Mt Cook)?

A "A mountain."

I "Same sort of mountain as Mt Egmont - or what's the difference?

A "It's (Mt Cook) colder."

I "Is it (Mt Cook) a volcanic mountain - do you think?

A "I don't think so."

I "Why not? Why don't you think it is?

A "Logic."

I "Logic? Tell me about this logic."

A "Instinct - yes, I go by instinct - it doesn't look like a volcano. This one here (Mt Egmont) is more open - individual." (406)

I "Is this (Mt Cook) from volcanic activity - do you think?

J "No."

I "Why do you say that?

J "Because there's too much on either side of it." (501)

Other explanations, as to how Mt Cook was formed, considered

(i) supernatural phenomena:

"God built it bigger and bigger." (104)

(ii) wind deposition:

"From materials being brought by the wind and that." (501)

(iii) underground pressure:

"There is probably a lot of pressure underneath it and it sort of built up and sort of exploded. Over a period of time it built up." (502)

(iv) tidal action:

H "I suppose it all has to do with water somehow."

I "Tell me about that."

H "Well .. with water - all washed away - it has changed in that way."

This last idiosyncratic idea, i.e. material being washed away, from around the mountain, was also forwarded (by student 606) to explain the evolution of Mt Egmont:

"It was washed away here (points to base of mountain) from the flat ground."
(606)

Ten students (1 x F3, 1 x F5, 4 x F6, 4 x F7) proposed ideas, for the development of Mt Cook, which involved related phenomena, such as earthquakes, fault-line activity and folding. However these terms were usually only mentioned with little elaboration:

R "They (Southern Alps) haven't been formed by volcanism, as far as I know."

I "They haven't been?

R "No ... they were formed by folding."
(704(g))

"It's (Mt Cook) in the middle of a fault-line." (602)

I "How does that (Mt Cook) get like that - do you think?

D "Oh - an earthquake. An earthquake could bring up a lot of land."

This particular mechanism wasn't seen to be applicable to all mountain building:

I "Do you always get earthquakes with mountain ranges - do you think?

D "No - some of them might just be there."

I "What - always been there?

D "Yes."
(305)

Seven students (1 x F5, 3 x F6, 3 x F7) mentioned some aspect of a 'plate theory' although none of these students was able to offer a detailed scientific view of mountain building via a theory of plate interaction.

Four students (1 x F2, 2 x F6, 1 x F7) envisaged a collision of plates as being the mechanism which resulted in the formation of the Southern Alps and Mt. Cook:

> "All I can say is about the two plates when they are pushed together - they form mountains and all this."
>
> (503)

The two plates, responsible for the development of the Southern Alps, were named by one student:

> "This is where the main Pacific - I think it is - and the Australian Plates meet all down the line."
>
> (603)

One plate was seen to be passing underneath the other:

> "One plate's going underneath the other and pushing one plate up."
>
> (605(g))
>
> I "What's happened in this case - do you think?
>
> C "Well, I think that they've collided and one plate's sort of ... as one plate's gone down the other one's twisted up on itself."
>
> (703)

Only one student referred to the relative movement of land at either side of the Alpine Fault:

> "The West Coast's moving upwards (North) and they (Southern Alps and Mt Cook) are are moving that way (indicates opposite motion)"
>
> (705(g))

The views that are held by children and adolescents, concerning these two landforms, are both varied and interesting. A comparison between students' views of Mt Egmont and those held by earth scientists are summarised in Table 1 whilst similar comparisons with Mt Cook are shown in Table 2.

STUDENTS' VIEWS OF MOUNT EGMONT CONTRASTED WITH SCIENTISTS' VIEWS

	SCIENTISTS' VIEW	STUDENTS' VIEWS	IDIOSYNCRATIC VIEWS
IS MOUNT EGMONT A VOLCANO?	It is a large strato-volcano built up from alternating deposits of lava and ash.	(a) Not a volcano (41%) (b) It is a volcano (c) It is an extinct volcano (22%) (d) It is a dormant volcano	(a) A mountain can become a volcano if it is shaken by earthquakes (b) A mountain with snow on top cannot be a volcano (c) Volcanoes are only found in colder areas e.g. Mt Erebus
WHAT IS THE ORIGIN OF MOUNT EGMONT?	Andesitic volcanoes may form when two tectonic plates (one being oceanic crust) approach and one underrides the other. Magma, formed by partial melting of down-going plate, rises to the surface.	(a) Mt Egmont has always been there (32%) (b) "plate tectonics" (c) crustal weakness (d) fault-line activity (e) pressure build-up (f) build up of lava	(a) Tides wash material away from around the mountain (b) Heat has to get out of the Earth (c) God created it
WHAT IS THE ERUPTIVE HISTORY OF MT EGMONT?	First eruptions about 70,000 years B.P. with a sizeable cone by 35,000 years B.P.. Large eruptions have occurred in the past with 4 'events' during the last 500 years. 'Recent' activity in 1755 with likelihood of future eruptions.	(a) No eruptions (41%) (b) Eruptions envisaged but no time scale known	(a) No changes will occur

Table 1

STUDENTS' VIEWS OF MOUNT COOK CONTRASTED WITH SCIENTISTS' VIEWS

	SCIENTISTS' VIEW	STUDENTS' VIEWS	IDIOSYNCRATIC VIEWS
IS MOUNT COOK A VOLCANO?	It is not of volcanic origin but part of the Southern Alps which have been uplifted via tectonic activity. Mt Cook originated as sedimentary rock and any changes (metamorpnism) have not occurred via volcanism.	(a) Mount Cook is, or was, a volcano (38%) (b) Part of a mountain range	(a) It could become a volcano if shaken by an earthquake (b) Volcanoes found only in warmer climates e.g. Krakatoa
WHAT IS THE ORIGIN OF MOUNT COOK?	The Southern Alps (including Mt Cook) make up an upthrusted range of mountains. Upthrust has resulted from the convergence and compression of two crustal plates. The Alpine Fault represents the boundary between the Indo-Australian and the Pacific plates.	(a) Mount [illegible]k has alway[illegible] [illegible]en there (27%) (b) "somet[illegible] n[illegible] [illegible]o do with plate collisions" (c) fault-line activity (d) earthquakes push up (e) folding (no mechanism)	(a) Wind deposition (b) Tidal action removes material and leaves mountain range (c) Underground pressure (d) God created it
WHAT IS THE UPLIFT HISTORY OF MOUNT COOK?	Changes in plate boundary motion have produced uplift of 10-20 km along the Alpine Fault over the past 20 million years. Uplift continues today at a rate of approximately 2-8 mm per year.	(a) No uplift process seen (b) Where plate collision is seen to provide the mechanism for uplift, no continued uplift seen today.	(a) No changes will occur

Table 2

SUMMARY :

The qualitative information, from this investigation, tends to suggest that children and adolescents hold views, about Mount Egmont and Mount Cook, which are likely to be different to the scientifically accepted ideas. The following points emerge:

1. Mount Egmont is a large stratovolcano. It is situated close to a number of Taranaki settlements and there is ample evidence to suggest that past mud and debris flows have reached Inglewood, Kapuni, Opunaki and Cape Egmont.

Despite the fact that this volcano is likely to erupt again in the future, approximately 63 percent of students interviewed were not aware that Mount Egmont has this potential. It would be interesting to ascertain whether, or not, students living in Taranaki hold similar views.

2. It has been the changes in plate boundary motion, along the Alpine Fault, which have largely controlled the geology of the South Island of New Zealand. Mount Cook is part of a mountain range which has been uplifted by this plate interaction.

Future research by earth scientists will inevitably focus on plate tectonics, in the New Zealand region, since this will almost certainly add to our understanding of sedimentary basin formation and the possible location of future oil and mineral deposits. Approximately 80 percent of students interviewed were unable to relate, in any way, to a theory of mountain building which involves plate tectonics.

3. It has been emphasised, within this paper, that New Zealand is situated astride a major plate boundary and, consequently, is an integral part of the circum-Pacific tectonically active zone. Volcanic eruptions and earthquake activity will always be a fact of life for many New Zealanders. A theory of plate tectonics which integrates volcanicity, earthquakes and mountain building should be an essential component in the scientific education of New Zealanders. This investigation has revealed that such an apprecation has not been attained by the majority of students, even at an elementary level of understanding.

ACKNOWLEDGEMENTS :

I would like to thank Roger Osborne, Peter Kamp, Michael Selby, Brendon Schollum and David Lowe for casting a critical eye over the first draft of this paper. Thanks must, as always, be extended to all those students who talked freely to me about the 'mysteries' of mountain building.

I am grateful to the staff of several schools for allowing me into their classrooms for interview purposes.

APPENDIX A

SECTION 4

Earth Science

AIM: To introduce students to the variety of landforms, rocks and soils; and through an investigation of their formation emphasis their changing nature. To involve students in outdoor observations and in a variety of communicative skills.

After completing this section, a student should be able to:

Content

1. a Identify the major landforms in his local area;
   b explain how these landforms may have been formed;
   c describe the agencies of change acting on these landforms including not only such agencies as volcanism, earthquakes, water, wind, ice etc, but also Man and his machinery;
   d explain the three major ways in which rocks are formed;
   e describe how different rock types give rise to different kinds of soil;
   f discuss how differences in landforms, rocks and soils influence Man's use of an area.

Skills

2. a Read simple geological and topographical maps of the local area;
   b classify rocks in various ways e.g. structure, hardness, colour;
   c observe and describe the characteristics of local rock and soils using a hand lens;
   d dig a soil profile and infer how the layers may have been formed.

Attitudes

3. a Appreciate the changing nature of the earth's surface and the importance of conservation practices;
   b show a willingness to expand their knowledge and interest in landforms, rocks and soils by continuing their personal observations investigations and reading.

SECTION 8

Earth Science

AIM: To extend the knowledge of land forms gained at level 4 by considering the earth's crust, the layered structure of the earth, its atmosphere, the dynamic nature of the surface layers and the geological history of New Zealand.

After completing this section, a student should be able to:

Content

1\. a Describe the plate theory of the earth's surface and discuss the evidence supporting such a theory;

b relate the plate theory to earthquakes, mountain building, volcanic zones and major fault lines;

c describe the theory of continental drift and discuss the evidence supporting such a theory;

d define a fossil and describe ways in which fossils may be formed;

e outline the major features of New Zealand's geological history;

f describe the formation of fossil fuels and discuss the importance of their conservation;

g define a mineral and discuss Man's use of minerals in New Zealand.

Skills

2\. a Produce charts, displays, models or other descriptions of the structure of the earth's crust, its dynamic nature or the geological history of New Zealand;

b group fossils, minerals and major rock types according to characteristic features.

Attitudes

3\. a Display a continuing interest in earth science, in Man's increasing knowledge of the nature and history of the earth's crust particularly in the South Pacific and in Man's use and conservation of his environment.

APPENDIX B

GLOSSARY OF TERMS

The following terms have been explained in a simplified way. More detailed definitions of terms may be obtained by referring to standard geological texts or the Dictionary of Geological Terms, compiled by the American Geological Institute.

ANDESITE: A fine-grained volcanic rock which is made up of minerals such as hornblende, biotite and augite. Andesite contains between 55% and 65% of silica.

ASTHENOSPHERE: A partially molten 'soft' layer of the Earth, located beneath the lithosphere. The asthenosphere is thought to be the layer in which convection currents exist.

BASALT: A dark-coloured, fine-grained volcanic rock, containing between 45% and 55% of silica.

BATHOLITH: A large body of intrusive igneous rock, at least 50 sq.km in area.

GRANITE: A coarse-grained igneous rock made up of quartz, feldspars and micas.

JURASSIC: A geologic time period which extended (approximately) from 200 million years B.P. to about 140 million years B.P.

LAHAR: A landslide or mudflow which occurs on the flank of a volcano. Water input may be from melting snow, heavy rainfall or crater lakes.

LITHOSPHERE: The outer, rigid layer of the Earth, comprising the crust and continents. The lithosphere is situated above the asthenosphere.

MAGMA: Molten silicate materials beneath the surface of the Earth. When magma reaches the Earth's surface, it is termed lava.

MIOCENE: The second time 'division' (epoch) of the Tertiary period, representing a time span of between 22 million years B.P. and 5 million years B.P.

MOUNTAIN: In a general sense, any landmass that stands conspicuously higher than its surroundings. Geologically it refers to parts of the Earth's crust having thick crumpled strata, regionally metamorphosed rocks and (sometimes) granitic batholiths.

PLATE BOUNDARY: An area of tectonic activity (usually along the edges of two interacting lithospheric plates. Such activity indicates relative motion between plates.

STRATA: The layered arrangement of the constituent particles of a rock body.

STRATOVOLCANO: A large volcanic cone which is stratified by means of alternating deposits of lava and ash.

TECTONISM: Crustal instability due to the interaction between lithospheric plates.

TERTIARY: That geologic time period which extended (approximately) from 65 million years B.P. to 2 million years B.P.

TRANSCURRENT FAULT: A fault in which the slip is in the direction of the fault trend.

TRENCH: A long, narrow depression of the deep-sea floor usually having steep sides. Deep oceanic trenches occur where crustal blocks descend into the mantle.

VOLCANO: A vent or fissure through which molten and solid materials and hot gases pass upwards to the Earth's surface.

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