PUPIL
RESEARCHER
INITIATIVE

Mars-ology

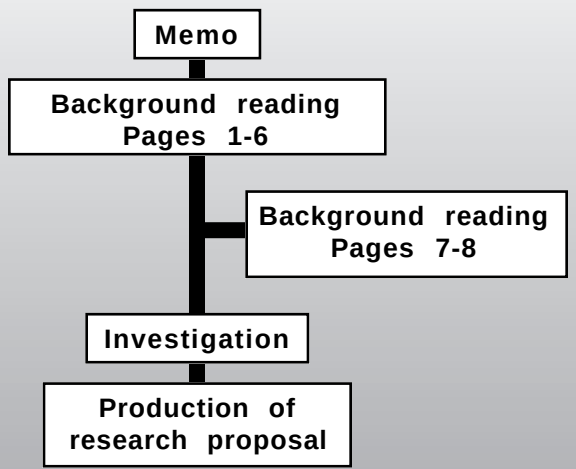
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ igneous rocks are formed from solidifying molten rock (magma)
- ❑ magma may rise through the crust to form volcanoes
- ❑ when molten rock erupts from volcanoes it is known as lava and forms extrusive igneous rocks
- ❑ when magma solidifies deep in the crust it forms intrusive igneous rocks
- ❑ different igneous rocks are made of different minerals
- ❑ igneous rocks are composed of randomly arranged, interlocking crystals
- ❑ if crystals are small, the rock probably formed from extruded lava and cooled rapidly, as in a volcanic eruption
- ❑ if crystals are large, the rock formed from magma that cooled more slowly, probably deep in the Earth's crust

Route through the Brief



Introduction

In this Brief the teacher and pupils take on the roles of research scientists at the Institute of Planetary Research: the pupils are new students, whilst the teacher is their research director. The Institute is putting together a proposal to NASA (the U.S. National Aeronautical and Space Administration). NASA is planning to send a series of space probes to Mars over the next few years and has requested ideas from researchers worldwide about what the probes could investigate during their missions. The pupils, in their roles as researchers, are asked to help in putting together ideas about the type of investigation which the Institute could suggest to NASA.

The Institute is developing theories about volcanoes on Mars. It is thought that they are caused by the same sort of processes which cause volcanoes on Earth. The Institute will therefore propose that the Mars probes investigate factors relating to the types of volcanoes on Mars and how they might have been formed.

Pupil Research Brief

Teachers' Notes continued

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Pupils should be familiar with the basic **structure of the Earth** (crust, mantle, inner and outer core), and **plate tectonic theory**, so that they can understand the significance of the range of causes of volcanic activity (subduction zones and hot spots). This may mean teaching plate tectonics before igneous rock types. It may also require the re-ordering of the teaching sequence of the Earth Science section of the scheme of work. However, the benefits are that pupils will have a better understanding of the origins of igneous rocks and the significance of tectonic activity in driving the rock cycle.

Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are:

Initial briefing - whole class; teacher-led introduction

Memo - whole class; led by teacher

Background science notes

Page 1-5 - individual or pairs

Page 6 - small groups

Page 7-8 - individuals or small groups (optional exercise)

Communication - individuals if written report is to be used for assessment purposes

Timing

The unit should take 2 hours of classroom time. Some of the work could be done as homework. Extra time may be needed to write up individual investigation reports if these are to be used for examination assessment purposes.

Activities

The teacher should issue the pupils with the **Study Guide** which provides pupils with a summary of what they should produce as they work through the Brief. It can also be used as a checklist so that they can monitor their own progress. The Brief shows how experiment and theory are tightly linked. The **Research Director** (teacher) issues each group with a copy of the **memo** which is addressed to the **principal investigator** (pupil selected by teacher). Each group also gets copies of the **background notes**, numbered pages 1-6 and possibly 7 and 8 (these could be omitted for some or all pupils). The aim of the work is to produce a section of the **Research Proposal for NASA**, outlining the suggested experiment(s) which the Mars probes could carry out.

The memo requires the pupils to work their way through the numbered pages of background notes from simulated books and journals. The Research Director has written comments on the notes which suggest things the research team should do. Pupils could keep track of which sections they have completed using the Study Guide.

Pages 1, 2 and 3 are meant to be extracts from a basic geology text. The pages outline some information about igneous rocks and the different types of volcano found on Earth. The description is very simple, and classifies volcanoes as being of two types - cone and shield volcanoes. The idea of a **shape factor** is introduced, which can be used to determine whether the volcano is a shield or cone type. This will be used when pupils deal with **page 4**. The calculation required (diameter / height) is one which most pupils should be able to manage with a calculator. The extract outlines the link between the shape factor and type of volcano. The pupils are led to think that the work on Earth volcanoes (calculating SF values, which give an indication of the type of volcano) can be applied to Martian volcanoes. However, some will conclude that just measuring volcano heights and diameters needs to be backed up by analysis of the rock types present in the volcanoes. Pupils may therefore suggest that the Mars probe needs to collect rock or soil samples from the volcanoes on Mars. This in turn may lead them to suggest that several probes will be necessary to cover different regions of the planet. In addition, **page 1** describes the effect of cooling time on crystal size (the longer the cooling time the larger the crystals). This may lead some pupils to suggest crystal size as a focus for one of the proposed Mars probe experiments.

Pupil Research Brief

Teachers' Notes continued

Volcano	Height(km)	Diameter (km)	SF(d/h)
Mauna Loa	4.169	90	21.59
Maui	3.085	40	12.96
Fuji San	3.776	30	7.94
Tenerife	3.715	40	10.76
Mount St Helens	2.549	25	9.80
La Palma	2.423	30	12.38
Tahiti	2.235	30	13.42
Nevado Ojos del Salado	5.887	8	1.35
Gran Canaria	1.949	45	23.08
Great Sitkin	1.740	9	5.17
Kanaga	1.312	10	7.62
Moffet	1.200	9	7.50
Reunion	2.631	35	13.30

Figure 1.

Volcano	Height(km)	Diameter (km)	SF(d/h)
Olympus mons	23.0	520	22.6
Ascraeus Mons	17.0	400	23.5
Uranius Mons	3.5	83	23.71
Ulysses Mons	4.0	91	22.75
Elysium Mons	9.0	170	18.89
Hecate Tholus	6.0	170	28.33

Figure 2.

Pages 4 and 5 are 'cut-and-paste' sheets put together by the Research Director. They include two tables of data and some annotations. The pupils use the SF equation from **page 1** to work out the SF values for the volcanoes in Table 1. The annotation to Figure 1 suggests that the pupils convert the volcano heights from metres into kilometres. Pupils should notice that there is a pattern which links volcanoes with SF values of less than 10 to cone type volcanoes, with shield volcanoes having SFs much higher. SF values are shown in Figure 1 above.

The pupils then move on to look at data on Martian volcanoes. They calculate SF values (again, converting metres to kilometres). They find that the SF values indicate shield volcanoes, but no cone volcanoes. Following on from their work based on **pages 1, 2 and 3**, they are again led to the suggestion that analysis of rocks from volcanoes is necessary to establish whether they are formed from the same, or different rocks. The absence of cone type volcanoes, linked to subduction zones on Earth, may lead some pupils to suggest that Mars does not show evidence of plate tectonic movement. Figure 2 shows the SF values for Martian volcanoes.

The SF calculations based on the data in Figure 2 show that Martian volcanoes are all of the shield type, possibly indicating a similar composition. Martian SF values are around 22, but with examples as high as 28 and as low as 18. Is this variation within the limits expected if volcanoes are composed of the same rock types? This may lead some pupils to argue further that the Mars probe needs to analyse rocks from these high and low SF level volcanoes.

Page 6 is handwritten by the Research Director, reminding them of the purpose of the activity - to suggest an experiment for the Mars probe which will provide evidence to back up the Institute's theory that volcanoes on Mars are caused by the same processes as those which form volcanoes on Earth. The Director suggests that they consider the effect of lava composition on flow-rates of lava - i.e., that different substances will have different flow properties. There is a hand-drawn sketch of a simple method of measuring flow which could be used by the pupils to begin planning their investigation. Research scientists often use an adaption of an existing technique to collect the data they are looking for without designing the approach from scratch.

Pupils need to hand in their investigation plans, so that they can be checked. Following the investigation, the pupils write up a report. Some pupils may link their conclusions about the results of the investigation to the outcomes of their work on **pages 1-3**. The investigation will show that different substances have different flow properties.

Pages 7 and 8 can be omitted for some or all pupils. **Page 7** describes recent and current planetary

missions, such as Mariner 4 and the Galileo mission. It sets out some of the issues which future Mars probes might investigate, adding to the source of ideas pupils may use in writing up their reports. **Page 8** is a summary chart showing planned Mars missions up to 2005.

By the time pupils have dealt with pages **1-6 or 1-8**, they should be able to write a research proposal for submission to the Research Director. This will include both the investigation report, and suggestions for one or more experiments which could be carried out by the Mars probe. The suggestions should be backed up by scientific explanations, such as: "The Research Team think that the Mars probe programme should collect samples of rock from a range of different volcanoes. Observation and measurement of Martian volcanoes indicates that they are of similar type, and therefore possibly of similar origin (based on SF values). However, the variation in SF values is sufficient to suggest that there may be some difference in composition. This might help shed light on the origin of the volcanoes and lead to further discoveries about the structure of the planet" . This is written in teacher language, but shows how the background knowledge built up during the unit can be used to formulate, and justify, a research proposal.

Investigation details

Page 6 contains suggestions for investigations. The diagram shows a possible way to measure "lava" flow. Possible variables pupils could investigate are temperature of the liquid, type of liquid (syrup, treacle, table jelly, various oils), crystal content (varying the amount of added sand) and gas content (blowing air bubbles into the liquid using a fine tipped pipette). Pupils could either measure distance travelled in a certain time, or time taken to travel a certain distance.

Pupils investigating factors other than temperature could do a trial run to establish at which temperature to run their test. Cold syrup, loaded with varying amounts of sand, will move very slowly down the tile. Syrup warmed in a water bath to around 40°C will move more quickly, and allow the effects of varying sand content to show up more clearly.

The memo asks pupils to suggest experiments which the Mars probes can carry out to provide further evidence for the hypothesis which states that similar structures on Earth and Mars are caused by similar processes. This will allow pupils to plan, but obviously not carry out, one or more investigations.

Technical details

Lava flow experiments can be carried out with any available viscous liquid. White tiles could be replaced with microscope slides.

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Protective eyewear should be worn when carrying out investigations using viscous liquids. This is particularly important if the liquids have been heated.

Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales, Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

Page 6 provides pupils with a basic investigative method which can be used to compare the flow rates of a range of substances, or the same substance under different conditions. This will have to be taken into account when assessing **Skill Area P**. The memo asks pupils to suggest experiments which the Mars probes can carry out to provide further evidence for the hypothesis. This is that similar structures on Earth and Mars are caused by similar processes. This could give rise to high marks for **Skill Area P**.

Skill Areas O, A and E may be restricted to middle level marks. However, if pupils use their evidence gathered in the 'lava' flow investigations, other information supplied in the Brief, and the results of further research into secondary sources, as a basis for the suggested Mars probes experiments, then they may reach higher marks for **Skill Areas A and E**.

Scottish syllabus coverage

The Brief covers Earth science topics, not required by Scottish Standard grade Science, Biology, Chemistry or Physics syllabuses.

Further pupil research opportunities

The Internet has some excellent examples of information, including data and images of the Mars surface showing possible volcano sites. Pupils could follow this up as an extended assignment.