GEOLOGY AND THE HUMAN ENVIRONMENT

The Nuclear Waste Problem

TEACHERS' GUIDE

Introduction
This is a problem solving exercise for AS geology students in schools and colleges. Originally these activities were presented to students during a study day at the National Museum & Gallery - Cardiff in a series of sessions led by geologists from the Museum and Cardiff University. The materials have been adapted for use in schools using resources available in most Geology Departments or from the Outreach Collection of the National Museum.

The pack has been written using the WJEC specification but it is also applicable to the OCR specification; it is designed to develop skills and techniques introduced through these AS courses.

Summary of skills and techniques developed in the pack:

Interpreting simple geological maps.
- Drawing simple cross-sections.
- Rock descriptions and identifications.
- Fossil identification and use for relative dating.
- Locating earthquake epicentres using seismograms.
- Interpreting volcanic monitoring data.
- Effect of longshore drift.
- Calculation of coastal erosion rates.
- Testing for permeability.
- Magnetic survey interpretation.
- Gravity survey interpretation.

Prior knowledge required
This exercise assumes relatively little geological knowledge since most of the ideas can be introduced en route. It does assume that students are familiar with the names "igneous, sedimentary and metamorphic" and that they are able to describe rocks. It is also assumed that students will have attempted simple cross-sections previously.

Time required
2 - 3 lessons (50/60 minutes each)

Scenario
Nova Cambria, a small island in the southern Pacific Ocean, has decided to use nuclear power to generate electricity. They have constructed a power station and need a site to store nuclear waste.

Role of the student
To take the role of a geological consultant to the Government of Nova Cambria. They will use a variety of geological and geophysical data to choose the most appropriate site for a nuclear waste facility.

Role of the teacher
The role of the teacher is to provide the background to each section and to demonstrate any unfamiliar skills. At the end of the exercise, the teacher will evaluate the recommendations of each student.

Procedure
The layout of the pack provides one possible route through the materials, but the sections can be attempted in any order provided that the students complete all activities fully.

Setting the scene
Begin by reading the following account about the island of Nova Cambria:

The island of Nova Cambria is in the southern Pacific Ocean, approximately 1000 km east of New Zealand. Generating electricity is a major problem on the island because, at present, it has no fossil fuel reserves. Mining was carried out in the past but the mines were abandoned long ago and mining records have since been lost. For many years the islanders have relied on imported fossil fuels, but this is now very expensive. Recently a deposit of uranium ore has been discovered and the island Government has decided to use it to generate electricity in a nuclear power station. The power station has been constructed but the problem is to find a suitable site for the storage of radioactive waste.

The islanders have selected five possible sites. Your job is to use the geological data on the island to evaluate these sites and to choose the most appropriate location for the waste facility. Alternatively you can choose to abandon the project altogether.

Getting started
Students will need their own copy of the student notes. In addition, they will need the usual writing equipment including a calculator, a ruler and a pair of compasses. During the practical sessions, students will need access to the specimens and equipment as listed below. It is expected that students will work together in the practical sessions.

Resources required for each section:
Section 1 - None

Section 2 - Specimens labelled as follows:

A limestone B sandstone C rhyolite/andesite
D shale E granite
Dilute hydrochloric acid (HCl), hand lenses,
TWO fossils of different ages e.g. trilobite labelled "from siltstone", ammonite labelled "from shale" (or plant fossils in shale)

Section 3 - None

Section 4 - Sample of volcanic sand (if possible), hand lenses.

Section 5 - Specimens listed as in section 2. Water with dropping pipette.

Section 6 - None

Section 7 - None

Suggested answers.
The exercise has been designed so that the students eliminate different sites as they work through the material. It is probably better for the teacher to avoid telling the students if they are right or wrong until they reach section 7. This provides an opportunity for discussion and students should be encouraged to justify their choices.

There is no clear "right answer".

Probable conclusions for each site:

Site A - unsuitable due to the permeable nature of the limestone (allows groundwater to infiltrate the site and to transport radioactive material) and the high rate of erosion at the coast.

Site B - unsuitable due to the permeability of the sandstone and its proximity to surface watercourses and population centres.

Site C - possible site since it is located on impermeable lava but the potential reactivation of the volcano is a serious risk. Students might describe ways of establishing a permanent monitoring station.

Site D - unsuitable site. Location is close to centres of population and surface watercourses. Site investigation geophysical surveys suggest the presence of old mine workings at site D.

Site E - suitable site. Groundwater cannot infiltrate impermeable granite but it is close to surface watercourses that could pollute the sea.

Alternative conclusion: Abandon the project - a strong possibility. Local tectonic setting means that Nova Cambria is prone to earthquakes, tsunami and (possible) future volcanic eruptions. If students choose this option, they must realise that the islanders will have no alternative source of power and the construction of the unused power station will leave the island's economy crippled.

Pre-exercise background
These areas should be addressed in preparation for the exercise:

1. Introduction.
Background to nuclear power, relationship of geology to nuclear power. Location of Nova Cambria and its geographical features. Factors affecting the choice of waste site.

2. The geology of the island.
Rock descriptions and identification. Use of fossils to determine relative ages. Drawing a cross-section from a simple geological map.

3. Tectonic setting.

Part A - Plate tectonics
Background to plate tectonics. Plate boundaries near Nova Cambria.

Part B - Seismic hazards
Recording earthquakes. How to read a seismogram. Plotting earthquake epicentres.

Part C - Volcanic hazards
Styles of volcanic eruptions. How volcanoes can be monitored and how such data can be used to predict future eruptions.

4. Coastal problems.
The action of the sea in eroding, transporting and depositing material. Calculating the rate of coastal retreat.

5. Groundwater movement.
How porosity and permeability can be determined. Relationship between groundwater and surface water.

6. Site investigations.
The stages in a site investigation. Desk studies, geological and geophysical surveys.

7. Conclusions
A process of evaluating the suitability of each site, according to the evidence produced, and of eliminating (with reasons) the unsuitable and recommending those (if any) that could seriously be used for nuclear waste disposal

[recommended references or background notes will be added in due course to this site to support the student's background research]