Learn Chemistry

Chemistry's Interfaces: Geochemical Time Travel

Resource Overview

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Introduction

This resource is designed as an introduction to geochemistry in the context of the geological and archaeological record. This problem is based around the following question: What would the geochemical record of human activities and civilisation be in the geochemical record of the future?

The resource is focussed at level 1 and 2 students so it places a particular emphasis on simple organic and inorganic chemical formulae and equations related to geochemistry and climate change science. Analytical techniques such as mass spectroscopy are also examined. No prior archaeological or geological knowledge is required or expected to complete this problem.

Many of the underlying concepts that students should understand in order to do this problem are covered in year one chemistry courses on organic chemistry and atmospheric chemistry. If students are yet to study some (or all) of these concepts, this problem could also be used to introduce the concepts alongside lecture – the problem will give students an opportunity to see how the geochemical study of the past can be used to predict the record of the future.

The range of applications covered in this problem brings together a number of different areas of overlap between chemistry, earth sciences, the physical and life sciences. This problem is unique in that it allows the students to utilise current research publications to produce a synthesis of information about this new and interdisciplinary area of scientific research.

The recommended reading is diverse in subject matter and there are extension papers for the more advanced questions. Although the problem has been primarily designed with year 1 and 2 students in mind, it could be used with year 3 or 4 students by utilising more of the extension papers and expanding some of the facilitation questions.

We recommend that this problem is used with small groups of students (typically group sizes of 4-6 work best). We also recommend that each facilitator guides no more than 2 or 3 groups at the same time – if a facilitator has to work with any more groups than this, it is likely to mean that very little time is spent with each group.

We have found that postgraduate students can make good PBL/CBL facilitators if they are given guidance in this style of teaching and the nature of the problem before the start of the module. It is advisable to have at least one staff facilitator on duty during all sessions.

Criterion	Value
Intended level	Year 1-2
Subject area	Geochemistry
Contact Hours	3-4 hours
Group size	4-6

Outline tutor answers have been provided for the facilitation questions in red script. Please note that these are neither model answers nor guidelines to the amount of content that students should produce. These answers only provide a minimal outline of the concepts being asked and students should go into more detail and provide examples of each of these concepts.

Additional information can be found in a glossary of geological terms at the end of this document. A PowerPoint Presentation duplicates the questions in this document, but also includes some useful images and additional background information. This presentation can be used as a reference or the illustration of tasks or key questions during the facilitation sessions.

Tutor text has been included in this version of the problem. The tutor text is shown in red; this text should not be shown to students.

Background

This resource was inspired by the recent global news debate and scientific coverage of The Anthropocene. This debate brought to light the fact that the significance of human impact on the planet may be to such an extent as to leave a measureable imprint in the geological record. In fact, The Anthropocene may be named as a new Epoch of geological time. This emerging new research area is highly cross-disciplinary,

(incorporating geology, geography, environmental science, climate science, materials science, biology and chemistry) but is in fact underpinned by chemical evidence.

The development team wanted to create a resource which could provide chemistry undergraduates with an insight into this interdisciplinary area by problem based learning and experience the importance of cutting edge global research. We hope to challenge the perception of how chemistry undergraduates think, and allow them to apply their subject knowledge in real-world scenarios.

One of the novel aspects of this resource is that it encounters the geochemical record through time, as recorded in rocks, soils and ice cores. Most of this record if a record of changes in the chemistry of the Earth's atmosphere or oceans. A different aspect that is addressed in the problem is the more tangible chemical composition and durability of a range of man-made and natural materials. The students will predict how these materials would be preserved in the 'Human Strata' i.e. the geological record of the future.

The resource was trialled at the University of the West of England (UWE) and Edge Hill University. Students engaged well with the resource well (student feedback included "*I wish I had more time to do this, it was great*" and "*I love detective work and was thinking of changing to forensic science, but now I realise that all science is about detective work*") and found the recommended reading accessible and informative. The resource also highlights the range of applications of the chemical sciences, one student commented ""*I thought that being a scientist was about working in a laboratory but now I realise just how much you have to know*". The resource was trialled with year 2 students, but the extended reading of scientific papers and extension activities also make this resource suitable for year 3 students. Students doing an environmental science module were especially engaged with the context of the problem and the aspects of pollution and the archaeological record. After the trial we reflect that this resource can be used with many different modules, such as atmospheric chemistry, organic chemistry and environmental sciences.

Transferable Skills Development

This resource makes use of a number of types of assessment which share a common theme of communication. The authors have found that the use of C/PBL resources can be an ideal way of teaching communication skills in a scientific context and it is hoped that this resource will raise awareness of the relevant issues when communicating science to a range of audience types. The following transferable skills are encountered in this problem:

- Discussing relevant aspects of science with peers **- Relevant throughout the problem**
- Working within a group to prepare a scientific poster – **Leading up to session 4.**
- Preparing a short (2-3 pages long) educational resource which will be used as a museum guide **– Leading up to session 4.**
- Presenting a scientific poster and answering relevant questions from peers – **Session 4.**

The Scenario

The scenario places the students in the role of staff working for the National Museum. They are tasked with organising a new exhibit which demonstrates how geochemical analysis can be used as a powerful tool to look back into the past and predict what evidence of our existence will exist in the geochemical record of the future.

Session 1 – Geochemical Time Travel

In Session 1 the students will be introduced to the problem: **"If humans were to become extinct would we leave a geochemical record behind?"** This is the theme that will be used for the new exhibit. It is central to the current debate on the naming of a new geological epoch, called the Anthropocene. The Anthropocene is the period of time in which humans have significantly altered our environment so much as to substantially change the geochemical record. The exhibit will examine the geochemical record of the

past, present and predict that of the future. This requires some understanding of geological time periods. At the start of this session the first task is to construct a time chart that encompasses the intervals that will be included in Parts 1-4 of this problem, encompassing 1 million years ago to 1 million years into the future. To introduce the key concepts of the Anthropocene the students will examine data presented in a recent key review paper by Steffen et al. (2011). The session also covers the 'Pre-Anthropocene' which will provide a discussion of the 'background' geochemical record of a time before humans altered the environment. At the end of the session students then have to decide which groups will do Session 2(b) and which Session 2(c) in the next session.

Session 2 – Geochemistry of the Anthropocene

In this session the students have the option of working on Session 2(b): The Early Anthropocene, or Session 2(c): The Great Acceleration. These optional units are **assessed** in the form of an A0 size poster for the museum exhibit, based on one of the key research questions for each part (a choice of four for each). These sessions can be run concurrently and some of the recommended reading is in common for both parts. Two optional extension task for both units are available; an oral poster presentation and producing an Open University Guide to the museum exhibition.

In Session 2(b): The Early Anthropocene, students will examine the geochemical record of human activities from 1000 years ago to 1945. In Session 2(c): The Great Acceleration, the geochemical record from 1945 to the present day will be examined. Both parts examine the durability of materials through time and which environmental changes will become a part of the geochemical record of the future. Important anthropogenic industrial chemicals are discussed and the analytical techniques used to examine them in the recent sediment record.

Session 3 – The Future

This session consists of 'The Future', a compulsory segment. The purpose of this section is to examine what the geochemical record of human activity and civilisation would look like in the record in 100, 1000 and 1 million years time. It also involves discussion on the durability and degradation of synthetic polymers, important long-lasting geochemical components of our future geochemical record. The geochemistry of the 'Human Strata' is then summarised, by considering the geology, climate history and geochemical markers. Students may wish to incorporate information from this session into their posters and present the posters in the extension Session 4.

This table below gives a summary of the organisation of the problem units:

Tutor text

The red text in this version of the guide is meant to be seen by the tutor only. This text includes guidance on how the problem can be run, marking criteria, feedback from the trials and some (where appropriate) example answers.

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Problem Unit	Research Questions	Summatively assessed?
Session 1: Compulsory Units: Introduction and 'Pre-Anthropocene'		
Introduction	What is the Anthropocene?	No
Session 1(a) Pre-Anthropocene	What is the background signal of climate change and how is this recorded by geochemistry?	No
Session 2: Optional Units: A choice of Session 2(b) or 2(c)		
Session 2(b). The Early Anthropocene	What evidence is there of human agriculture, industry and technologies in the geochemical record?	Yes
Session 2(c). The Great Acceleration	How will modern day materials, chemicals and structures be preserved in the geochemical record of the future?	Yes
Session 3: Compulsory Unit: 'The Future'		
Session 3(d) The Future	How will the geochemical record of our human civilisation be preserved in the geochemical record of the future?	Yes
Extension Session 4: Poster Presentations		Yes