HADRIAN'S WALL
COMMUNITY ARCHAEOLOGY

INVESTIGATING WALL STONE (7)

Taking it Further

ABSTRACT

This guide provides information to help take your understanding of the geology of the Hadrian's Wall area further. This includes a resources list and further reading

Ian Kille

Newcastle University

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Contents

Introduction

The material presented in this series of guides, Investigating Wall Stone, gives the basic information about what is to be observed and recorded to enable the research for the Stone Sourcing and Dispersal Project. It also gives some of the background to explain why the variation in stones occurs and to explore how geological processes operate. This is not only a rewarding subject, but one which is rich in its breadth and depth and it will be clear that there is much more to learn about geology and the way in which it interacts with Hadrian's Wall.

This guide is intended to help with further geological exploration, first as an explanation of some of the additional things that will be carried out as part of the Stone Sourcing and Dispersal Project and secondly to point towards resources that will help with further exploration of the subject.

The additional Stone Sourcing and Dispersal work is about laboratory work and the studies of petrography and geochemistry. These studies can provide useful information about the nature of the stones and can be used to both complement as well as inform and improve field observations. Whilst some of this work will need to be carried out by members of the WallCAP team there are opportunities within this for all to be involved.

There is much that may be read about geology in papers, books and online, and as part of this guide some of the more relevant, interesting, and well-presented examples are highlighted. Ultimately though, learning about geology is best done by looking at rocks in the field so that the relationships between different rock types may be seen. Some suggestions about how to get involved in field work have therefore been made below.

Geological Process

The guides have focussed on the geological process that affect sandstones and other clastic rocks as these are the principle building materials for the Wall. These are not the only rocks which define the landscape or indeed form part of the Wall's structure. Limestones and coals are interbedded with the sandstones and large amounts of sand, gravel and clay are draped over the landscape. The Whin Sill is an important element of landscape particularly where it forms the dramatic crags in the central section of the Wall.

There is more to be explored about the way that sandstones are formed and classified (see below) and as much again about the formation of the other types of geological material. Stuart Jones Introduction to Sedimentary Rocks is a good place to start with the sedimentary rocks. Understanding how volcanoes work is a good way of getting into the sort of igneous processes which formed the Whin Sill and Dougal Jerram's Introduction to Volcanoes provides a good way to start exploring this.

The Geological History of the Hadrian's Wall Area.

By exploring the geological history of the Hadrian's Wall area, it is possible to build up a picture of the way in which the landscape has been constructed. This is invaluable to understanding the context in which the Wall was built. It also gives a sense of the range of materials available for wall building, where they are placed in the landscape and to which geological periods these different materials are specific. This latter is particularly valuable in helping to understand where the source materials for the Wall may have been located.

As already noted, fieldwork is the key to understanding this. There are however several books which help with this exploration by describing the geological history of the Wall area and by giving guided walks to follow.

Classifying Rocks, Taking it Further

The formal classification of rocks, including sandstones, has been lightly touched upon within the guides. The formal subdivision of clastic rocks according to their grain size is an example. Many other, and more detailed classification systems have been devised by geologist with the aim of identifying the rocks in such a way as to highlight how the rocks have formed and to give common terms for comparison.

Whilst it is not strictly necessary to understand these classifications for the stone Sourcing and Dispersal Project, they may nonetheless give a better insight into the stones which are being examined. They may also provide an interesting challenge for anyone wishing to advance their understanding.

Many of the pieces of data collected in the Stone Sourcing and Dispersal Project - grain size, grain sorting, ratio of cement to grains, porosity, ratios of grain types - are used as the basis for other formal classifications of sandstones and other clastic rocks. This means that volunteers will already have much of the raw information to be able to extend their knowledge in this field.

The reading list identifies several texts which will help with this. Stuart Jones Introduction to Sedimentary Rocks is a good place to start. This subject is also open for discussion on geo-walks. As noted above one of the best ways to learn about geology is by interrogating the rocks in the field.

Field Work

The WallCAP project offers a series of geo-walks which are principally aimed at giving and understanding of different aspects of the Wall area's geology. These walks also offer training in how to observe, record and identify different rock types.

There are other organisations which run geological field trips within the Hadrian's Wall area and in areas which have geology which relates to Hadrian's Wall. The following is a list of these groups and how to contact them online:

Northumbrian Earth: Runs geodiversity walks in Northumberland and the Borders, privately and in partnership with other organisations (e.g. the Northumberland Coast AONB and the Northumberland National Park). https://www.northumbrianearth.co.uk/

North East Geological Society (NEGS): An active group with regular field trips covering Newcastle, Northumberland and Co Durham. https://www.negs.org.uk/

Open University Geological Society Northumbria branch (NOUGS): An equally active group running regular field trips in the area. https://ougs.org/northumbria/

Natural History Society of Northumbria (NHSN): More focussed on wildlife but does run geological events and provides useful resources at the Great North Museum. https://www.nhsn.ncl.ac.uk/

Cumberland Geological Society (CGS): An active society running regular walk and talks including the western part of the Hadrian's Wall Area. http://www.cumberland-geol-soc.org.uk/

In addition to this, everyday can be a field-work day! We are surrounded by natural geological resources both in the countryside and in towns. The field guides listed in the "Further Reading" section give specific geological excursions which may be followed and where particularly interesting rock exposures may be found. These are useful as they help with interpretation of what it is you are looking at. Once the basics of rock identification have been mastered, it is also possible to make your own observations supported by internet research including the interactive BGS geological map, the Geology of Britain viewer. The BGS map can be viewed via a web browser http://mapapps.bgs.ac.uk/geologyofbritain/home.html or can be uploaded as an app.

Observing and recording data in the Laboratory

Much information can be gleaned from a visual inspection of stone with the naked eye and using a hand lens. However, more detailed, and more quantitative information can be obtained back at the lab. Two further techniques will be used as part of the Stone Sourcing and Dispersal Project: polarising microscopy using thin sections, and geochemical analysis.

The Polarising Microscope and Thin Sections

One of the issues which becomes apparent with sandstones (and many other rocks) when you start trying to identify mineral grains is how difficult this is to do with a hand lens. This is partly because the grains are often small but also because the one small face of the grain you can see may not give sufficient features to be able to definitively identify it.

Thin sections and a polarising microscope allow for much better identification of mineral grains and for the observation and identification of finer grains including the material cementing the grains. They also allow for a more rigorous analysis of the shape of grains, how the grains relate to each other, the percentage of different mineral types and the amount and type of pore space.

Once a specimen has been examined in thin section it then makes it easier to see what is happening in a hand specimen and to improve one's technique for identifying minerals and rock texture in the field.

This is a powerful technique used by geologists in almost every field of work. Whilst it will not be practical to ask volunteers to do this sort of work, workshops will be organised for volunteers to see how this works and what rocks look like down a microscope. The technique is also limited in its use as it is destructive of the stone samples.

The method works as follows: thin sections are made by cutting a slice from the stone sample as thin as is possible using a diamond saw. With crumbly sandstones a thicker slice will need to be taken and impregnated with resin. The slice of rock is then adhered to a glass slide with epoxy. The slice is then ground and polished to a precise thickness of 30µm. At this thickness almost all minerals become transparent and it makes it possible to accurately observe their optical properties.

The polarising microscope allows for the optical properties of the minerals to be interrogated. The polarising microscope has two polarising filters which can either be oriented in the same direction (plane polarised light) or at 90^{o} (cross polarised light). The microscope also has a rotating stage which allows for the minerals in a thin section to be freely oriented. The crystal symmetry of a mineral controls the way that light passes through it. For many minerals, if you shine a light through a single crystal, the amount which that light is refracted will depend on the orientation of the crystal. The double refraction which is seen in calcite crystals is an example of this happening. This property is known as birefringence and minerals like this are referred to as anisotropic. The strength of birefringence can be directly observed in cross-polarised light as different strengths of birefringence produce different colours, or birefringence patterns.

Density differences can also be observed in plane polarised light. Minerals of higher density will have more defined outlines.

Birefringence patterns and the grain "presence" in plane polarised light allow most minerals to be relatively easily identified. There are other specialist techniques which may be used to further identify particular mineral types.

Geochemical Analysis

There are a variety of techniques which allow for the accurate measurement of the percentages of different chemical elements to be found within a rock. Chemical elements in rocks are referred to as either major elements (those commonly found in rocks) and trace elements (those only found in small quantities).

X-ray Fluorescence Spectrometry (XRF) is a reliable method of obtaining measurements on a wide range of major and trace elements. The most accurate measurements are made using a lab-based machine, where samples are taken from fresh rock (with no weathering) which has been finely crushed in a contaminant free environment. Good, but more qualitative measurements may be taken using a portable device. To enable the measurement of Wall-stones in situ the portable device is clearly essential.

As with the thin sections it is not practical for volunteers to carry out this work, not least because radiation training and dosage measurement is required. Volunteers will be shown how this analysis is carried out and will have access to the data which this work produces.

Further Reading

The Wall and Geology

Geologists Association Field Guide 59. Hadrian's Wall (1997): Geology of Hadrian's Wall by G.A.L.Johnson.

Ancient Frontiers: Exploring the Geology and Landscape of the Hadrian's Wall Area (Earthwise Guides)

Introduction to Sedimentology and other aspects of geology

Introducing Sedimentology (2015) by Stuart Jones

Introducing mineralogy (2014) by John Mason

Introducing Volcanology: A Guide to Hot Rocks (2011) by Dougal Jerram

Introducing Geology – a guide to the world of rocks (2018) by Graham Park

Introducing Tectonics, Rock Structures and Mountain Belts (2012) by Graham Park

The Geology of Britain Paperback (2002) by Peter Toghill

Field Excursions including the Wall area and on Wall related rocks

Northumbrian Rocks and Landscape, A Field Guide: Edited by Colin Scrutton, Yorkshire Geological Society. (out of print but sometimes available second hand)

Northumberland Coast Rocks! (2019) by Helen Page and Ian Kille.

More detail on the region's geology

The 5th edition of British regional geology: Northern England. 1 Jan 2010 by P.Stone (Author), D. Millward (Author), B. Young (Author)

Geodiversity

Northumberland National Park : geodiversity audit and action plan (2007) by

Lawrence, D.J.D.; Arkley, S.L.B.; Everest, J.D.; Clarke, S.M.; Millward, D.; Hyslop, E.K.; Thompson, G.L.; Young, B (available online)

North Pennines Area of Outstanding Natural Beauty and UNESCO Global Geopark Geodiversity Action Plan (2018) (available online)

Interesting books on general geology

Timefulness: How Thinking Like a Geologist Can Help Save the World (2018) by Marcia Bjornerud

The Floating Egg: Episodes in the Making of Geology (2011) by Roger Osborne