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Current status and future development of the BGS Rock Classification Scheme

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BRITISH GEOLOGICAL SURVEY

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Current status and future development of the BGS Rock Classification Scheme

M T Styles, M R Gillespie, W Bauer and G K Lott

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Parent Body

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Foreword

This report is the published product of a study by the British Geological Survey (BGS) covering the BGS Rock Classification Scheme (RCS). The RCS was developed at BGS in the mid 1990s to create a comprehensive, consistent scheme for the classification of rocks for all BGS uses and the creation of digital dictionaries for use in corporate databases. This was particularly important for the amalgamation of extensive legacy data in the production of the digital geological maps of the UK. The scheme is widely used in BGS and has been adopted by many organisations worldwide, but is now almost 10 years old and due for correction and updating in light of experience and comments during that period.

1 Acknowledgements

We thank Steven Brearley for compiling the web statistics about the downloads of the RCS from the BGS web site and Dr A Howard for a helpful review.

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Summary

This report describes the current status of the BGS Rock Classification Scheme (RCS) and possible plans for its maintenance and on-going development. It describes the impact of the RCS since publication in 1999, worldwide developments in rock classification and how this affects the standing of the RCS. Options are suggested for ways to update, enhance and maintain the RCS. A detailed review of the existing schemes has been carried out and a plan to amend and improve them is proposed.

2 Introduction

The BGS Rock Classification Scheme (RCS) was devised between 1993 and 1996 in response to a need from the Digital Map Production System project. There was a requirement for a consistent and comprehensive scheme for classifying and naming rocks and deposits, and for associated computer dictionary tables to enable diverse legacy datasets to be amalgamated, from which a new digital geological map of the UK could be developed. The RCS was published as a series of BGS Research Reports in 1999 and made available as a free download from the BGS web site. The original RCS was published in four volumes; Igneous rocks, Metamorphic rocks, Sedimentary rocks and Artificial and Superficial deposits. The latter is now being covered by separate schemes and this report deals only with the three traditional rock types.

At the time the four original volumes of the RCS were produced, the only published internationally used English-language scheme that dealt comprehensively with classification and nomenclature of any of the main rock classes was that published by the IUGS Subcommission on the Systematics of Igneous Rocks (Le Maitre et al., 1989). No schemes existed for metamorphic or sedimentary rocks and no other geological survey had produced a scheme comparable to the RCS. Significant developments since 1999 include the publication of a second edition of the IUGS recommendations for classifying igneous rocks (Le Maitre et al., 2002), web-publication of IUGS recommendations for naming metamorphic rocks, and development in North America and Australia of rock naming and classification schemes to support geological data models and field mapping.

The RCS has been downloaded by 10s of thousands of people and organisations, has been widely acclaimed as a clear and comprehensive scheme, and has been partly or wholly adopted by many organisations worldwide. The RCS is therefore a ‘flagship’ BGS product. The recent international developments and the experience of five years use of the RCS in BGS have demonstrated a pressing need to revise the RCS and to devise a plan for on-going development and maintenance of the scheme. This report presents a review and plan for development.

3 The worldwide impact of the RCS

The RCS was released on the BGS web site in 1999 but statistics about downloads are only available since July 2000. In less than six years volumes of the RCS have been downloaded over 30,000 times and the monthly download data are shown in the Appendix. Figure 1 shows the total number of downloads along with their average position in the site download popularity during that period.

	Igneous		Sedimentary		Metamorphic		Superficials		Total
	Downloads	Position	Downloads	Position	Downloads	Position	Downloads	Position	Downloads
Total	10704	4	10881	6	6363	11	5434	14	33382

Figure 1. Total number of downloads and the average position in popularity since July 2000.

This shows that the schemes have been downloaded a huge number of times and that the main rock schemes covered by this review are some of the most popular downloads from the BGS site. If we look at this in more detail, taking note of the variation over time (Figure 2), we can see that along with the steady growth of the popularity of the BGS web site as a whole, there has been a similar growth of the RCS, particularly the igneous and sedimentary schemes increasing from around 30 per month to 300 per month.

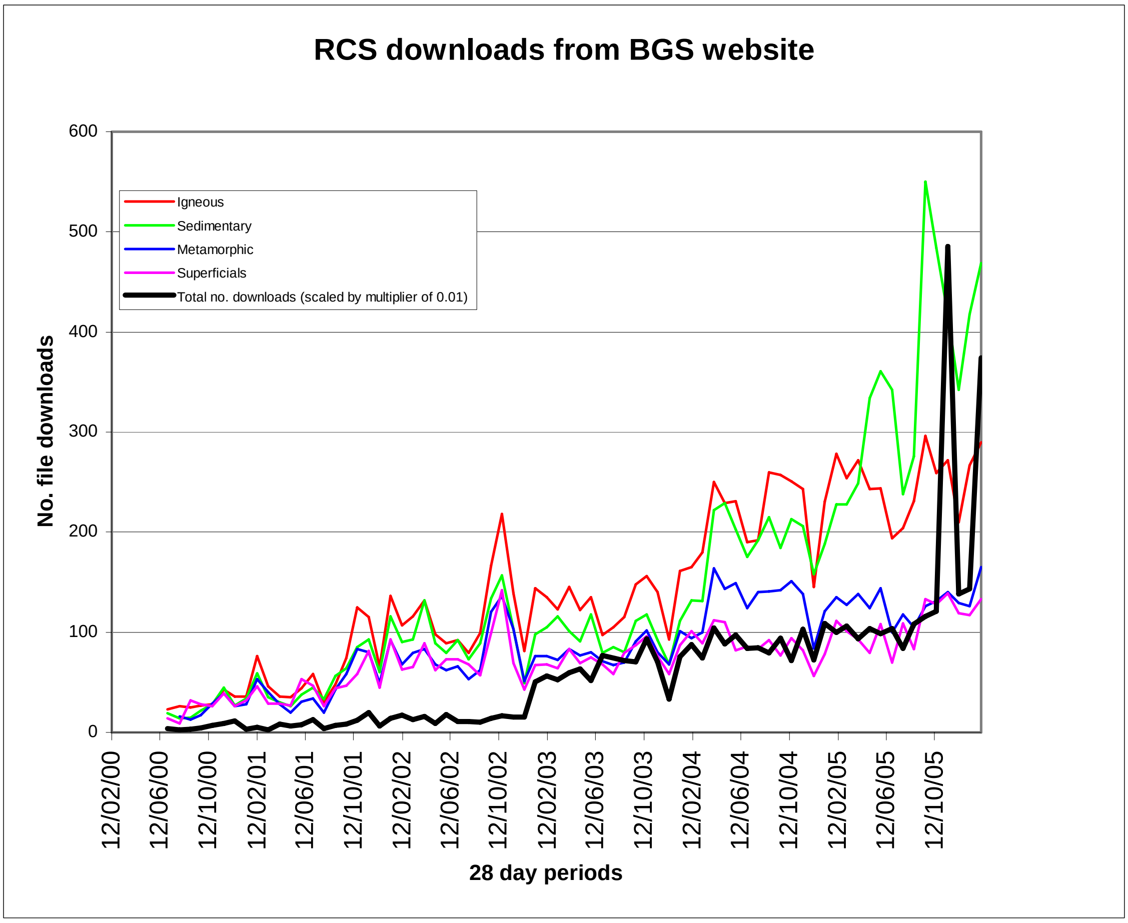

Figure 2. The number of downloads of the RCS volumes on a monthly basis.

The monthly download positions (Figure 3, show that the schemes have consistently been some of the most popular downloads and that the Igneous and Sedimentary schemes have never been out of the top five for the last two years. If all the schemes are added together and considered a single product it is probably the most popular in the whole of BGS.

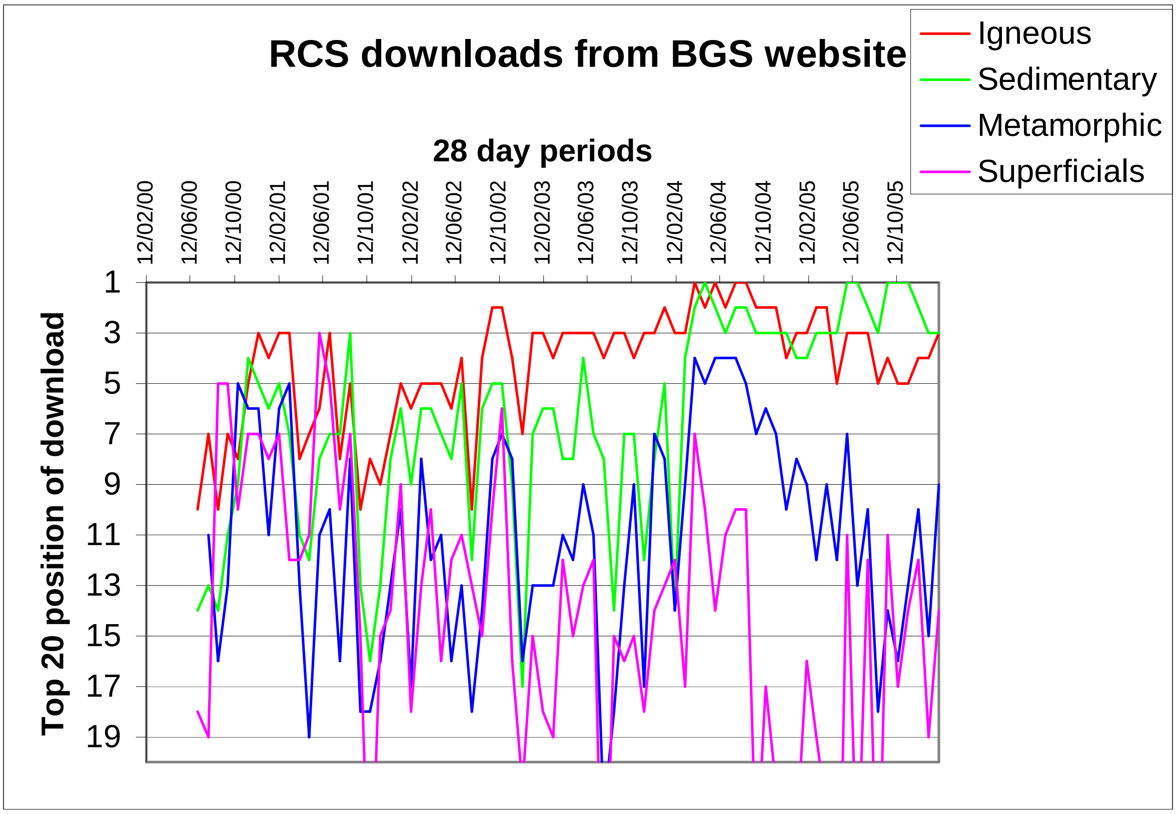

Figure 3. Position of the RCS volumes in the top BGS downloads.

The data given here show that the RCS is indeed a BGS flagship product, and although in need of revision is BGS' most popular download product. The RCS is therefore one of the most common 'faces' of BGS to the outside world and something people are likely to have around, quote in reports and show to others. It is a product that can greatly enhance the image and reputation of BGS.

4 International developments

The RCS was developed in the mid 1990s and at that time there was little general interest in the development of rock classification schemes. However, a massive increase in the use of computer databases and associated GIS applications for analysing geological data has led to a much greater awareness of the importance of such schemes, and an increase in activity worldwide. A summary of the most important developments is given in the following sections.

4.1 INTERNATIONAL UNION OF GEOLOGICAL SCIENCES (IUGS) COMMISSION ON SYSTEMATICS IN PETROLOGY

One of the principal aims of the IUGS Commission on Systematics in Petrology is to strengthen international co-operation and scientific communication by producing rock classification schemes for igneous, metamorphic and sedimentary rocks that are accepted internationally. The Commission has three active subcommissions, one each for igneous, metamorphic and sedimentary rocks. Each is at a different stage in the process of creating an internationally accepted classification scheme.

The Subcommission for igneous rocks (SCIR) first published its recommendations in 1989 (Le Maitre et al., 1989). Volume I (Igneous Rocks) of the BGS Rock Classification Scheme is based to a large extent on the recommendations set out in this book. However, the Subcommission continues to be active, and a second edition of the book was published several years ago (Le Maitre et al., 2002). Though much is unchanged from the first edition (including most of the sections covering the more common igneous lithologies), the second edition contains a number of important corrections and updates, notably to those sections covering rare, 'exotic' lithologies. More recently, the Subcommission has been working on the possibility of using the total alkalis *vs* silica (TAS) classification system (which is used currently to classify fine-grained igneous rocks) to classify coarse-grained igneous rocks. There are to date no published recommendations, but this development may in due course lead to a further significant modification to the IUGS recommendations. The SCIR is also in the process of creating a web page.

The IUGS Subcommission for metamorphic rocks (SCMR) was established in 1985 but was unproductive compared to the SCIR. By 1999, when the RCS was published, the SCMR had produced a few preliminary draft documents but was still several years from producing a comprehensive scheme for metamorphic rocks. Nevertheless, the principles being followed by the Subcommission at that time were considered during preparation of the BGS scheme for metamorphic rocks (RCS Volume 2). The stated aim of the SCMR is to produce a unified *nomenclature* scheme for metamorphic rocks; the emphasis is placed on nomenclature because it is recognised that metamorphic rocks may be classified in one or more of three different ways (i.e. with the bias towards protolith, texture or composition). The current stated objectives of the SCMR are to initially publish its recommendations in a series of eleven papers on its website (http://www.bgs.ac.uk/SCMR/) and in due course as a book that would also contain a comprehensive glossary. The eleven titles are listed in section 6.2.1 covering the Metamorphic scheme. The SCMR website currently indicates that six of the papers have full 'recommendation' status, three have 'provisional recommendations' status, and two are described as 'proposal, in preparation' and have no information available.

An IUGS Subcommission on the systematics of sedimentary rocks is in the process of being established (or re-established). No recommendations have yet been produced, and significant progress is likely to take several years at least.

4.2 SCIENCE-LANGUAGE PROPOSALS PRODUCED IN SUPPORT OF THE NORTH AMERICAN GEOLOGIC MAP DATA MODEL

In North America, the main driver for standardising rock classification and nomenclature has been the North American Geologic Map Data Model (NADM). The NADM Steering Committee (NADMSC; a successor to the Data Model Working Group set up by the US Geological Survey/ Association of American State Geologists/ Geological Survey of Canada) is a consortium of American and Canadian geoscientists, database designers, and developers of geological map information that sponsors and facilitates cooperative development of digital infrastructure for geological map databases, working on behalf of its sponsoring agencies to develop products and ideas that can be adapted as agency standards. NADMSC first convened in February 1999, with the broad goal of developing standardized methodologies for storing, manipulating, analysing, managing, and distributing digital geological-map information.

Several 'Technical Teams' were established, each charged with developing a piece of the infrastructure required to support geological map databases. The Science Language Technical Team (SLTT), a diverse group of scientists from a variety of American and Canadian geoscience and resource agencies, and from academia, was established to develop standardized science language for use in public-sector geological-map databases. SLTT's stated purpose was "to develop a science-language standard for the description, classification, and interpretation of earth materials in geologic-map databases. The language should provide a logical, consistent, hierarchical framework for naming and classifying earth materials, and for describing their physical characteristics and genesis. Most importantly, the language should be based on the way geologic maps are made by the field geologist or assembled by a science compiler."

Between April 2000 and November 2004 the SLTT developed a prototype science language for naming and describing Earth materials in digital geological map databases produced by public sector entities in North America. The SLTT adopted major elements of the BGS approach, as set out in the RCS, but “found that in order to accommodate North American geologic-mapping traditions and approaches we had to develop slightly modified terminology and taxonomic hierarchies”.

The SLTT split into subgroups organized around the major classes of Earth material: ‘plutonic’, ‘volcanic’, ‘metamorphic’ and ‘sedimentary and surficial materials’. Differences in philosophy among the SLTT participants led to science-language approaches that differed from subgroup to subgroup, with the result that the final SLTT documents do not have commonality of purpose, content or scope.

The ‘plutonic’ SLTT subgroup was unable to develop recommendations for a science-language standard; in the interim, the NADMSC has recommended that the BGS RCS Volume I (Igneous Rocks) be used for North American geological map databases. The ‘volcanic’ SLTT subgroup focused on how to bring the variable and inconsistent usage of legacy geological maps into a modern database. To accomplish this they characterised volcanic materials using three fundamental classes: composition, texture and emplacement characteristics. The report provides informal characterisations of volcanogenic materials in terms of these three aspects, but does not provide formal material descriptions, deferring instead to other sources (such as Le Maitre et al., 2002). For metamorphic rocks, the BGS recommendations (RCS Volume 2) and preliminary recommendations of the IUGS SCMR were adapted to meet SLTT database requirements. Metamorphic rocks are classified along two orthogonal dimensions, both of which are hierarchical. This yields a classification that is a directed acyclic graph rather than a tree. Class names for rocks thus have a ‘fabric’ and a compositional component.

SLTT produced a huge volume on sedimentary and superficial deposits that covers the BGS volumes and adds a lot of extra detail in some areas. The sedimentary scheme essentially follows the BGS scheme and quotes and discusses it in many places.

SLTT reports have been posted on the NADM website as a ‘work in progress’, with a view to eliciting discussion and feedback among the geological mapping community, without the need to publish a formal science-language document.

4.3 GEOLOGICAL SURVEY OF WESTERN AUSTRALIA REVISED ROCK CLASSIFICATION SCHEME

GSWA has recently published a ‘revised’ rock classification scheme (Tyler et al., 2004) that, oddly, contains no reference to an original publication, so the history of its development is not clear. The scheme is clearly specific to GSWA, and appears to be unique in Australia; none of the other organisations responsible for geological exploration at state government level in Australia appears to have developed a similar scheme. Geoscience Australia, the national agency for geoscience research and geospatial information, has developed ‘Geoscience Data Standards’ (documented technical specifications) that are used to ensure that datasets and products are fit for their purpose. However, a standardised scheme for rock classification and nomenclature appears not to be a part of this.

The ‘revised’ GSWA scheme is a four-tier hierarchical rock classification scheme designed to provide a consistent approach to lithological (igneous, metamorphic and sedimentary rock) nomenclature within GSWA. GSWA is a field-based organisation, hence the scheme is designed specifically for features observable in the field, in hand specimen, and in thin section. Exactly the same scheme (in terms of approach and nomenclature) is used to classify individual rocks and rock units. The highest-level divisions (igneous, sedimentary and metamorphic) are divided following the principles of established or proposed international schemes (mainly the IUGS recommendations for igneous and metamorphic rocks, and the schemes of Dunham [1962], Tucker [1991] and Dott [1964] for sedimentary rocks; the BGS RCS is not mentioned). The scheme is therefore largely unoriginal with respect to primary rock classification.

The following example of how sedimentary rocks are classified illustrates how the scheme works: a primary code denotes the broad compositional class of a rock or unit (siliciclastic, carbonate, other chemical, or biochemical); a secondary code denotes grain size; a tertiary code denotes a more specific composition; and a quaternary code denotes environment of deposition. Thus, a polymictic conglomerate interbedded with sandstone, the whole being of glacial origin, is given the code 'sgpg' (siliciclastic-conglomerate & sandstone-polymictic-glacial); the same code would apply to an individual rock and to a rock unit/map polygon.

The scheme is designed to suit the specific needs of GSWA, and contains no elements that might be adopted in a revised BGS RCS.

4.4 SUMMARY OF INTERNATIONAL DEVELOPMENTS

Recent developments by the IUGS Subcommissions on igneous and metamorphic rocks are directly relevant to the BGS RCS; their recommendations should be assessed carefully and incorporated where appropriate in the proposed revision of the RCS.

All of the schemes for 'rock classification' developed since 1999 in organisations charged with geological survey/exploration (specifically in North America and Australia) have at least in part adopted one or other, or both, of the approaches set out previously by the IUGS (Le Maitre et al. 1989, 2002) and in the BGS RCS. However, the principal drivers for these schemes have been to standardise the nomenclature and approach used in map-making by different public-sector users (i.e. the national and state/provincial geological surveys in North America and Australia, separately) and to provide standardised methodologies for storing, manipulating, analysing, managing, and distributing digital geological-map information. These schemes typically involve multiple hierarchical systems designed to permit widely applicable thematic querying of bedrock geological databases. They are not concerned with rock classification, but rather with rock unit classification, and are therefore not directly relevant to the proposed revision of the RCS.

5 Strategy to revise and enhance the RCS

Revision and development of the RCS could be carried out in several different ways but these essentially fall into two options:

a) simple correction and updating of the existing reports;

b) development and enhancement of the RCS to be an international flagship product for BGS that builds on its existing wide usage and promotes BGS as an originator and supplier of high quality Geostandards. It is a product that can greatly enhance the image and reputation of BGS. At the moment it is a world leading scientific product but in a routine and dull package, a Rolls Royce engine in an Escort van. Several years ago the RCS was adopted for the commercial mining industry product MineMatch. The company who did this said the RCS is the best and only comprehensive system in the world and BGS have the opportunity to be the Microsoft of Rock Classification. We still have the chance to catch the boat before it is too late.

Option a) must be done to maintain the credibility and usefulness of the RCS, both within and without BGS. These are essentially 'technical' improvements, and a review of them and an outline of what needs to be done are given in section 4. This covers issues such as clarifying their purpose, updating of relevant sections, correcting errors, harmonising layout and format, and checking consistency with related BGS applications such as the lithostratigraphical and lithodemic 'classifications'. It also includes a thorough review of certain features that were devised specifically for the original scheme, such as the BGS grain-size scheme and compulsory use of hyphens in formal rock names. This would ideally involve a small working group to include a wider range of views than those of the scheme authors. Option a) would yield a technically improved product that looks more or less the same as the previous version.

Option b) would include all the technical improvements of option a) but would also focus on improving the appearance and appeal of the products and consequently their acceptability, popularity and usage. There are possibilities to market and sell derivative products that would raise money and, perhaps more importantly, promote BGS worldwide as a brand and a supplier of high quality geostandards. The sort of enhancements we have in mind include:

- Add a comprehensive Glossary of approved rock names and definitions, with cross-reference to appropriate diagrams (and possibly photographs). The Glossary would allow the RCS to be used as a rapid reference source for approved rock names (and should include names not approved by the scheme and their translation), which would increase its appeal considerably and make it more user-friendly than it currently is.
- Some rewriting of text to create a more lively and user-friendly style.
- Use of colour, particularly in diagrams, and inclusion of photos of rock samples and thin sections to illustrate rock types, textural variants etc.
- Inclusion of more examples and scenarios that demonstrate how the RCS works.
- High quality presentation throughout, including better use of features (including logos, fonts, layout etc) that emphasise the BGS 'brand'.
- Combining the schemes and publishing the BGS RCS as a book.
- Producing an electronic 'book' with hyperlinks to relevant, figures, photos etc.
- Producing a condensed version based largely around the classification diagrams, with minimal text, to be used as a reference source that complements the full version.
- Produce the condensed version as a series of laminated cards, similar to those used in the geologists field notebooks. These might be attractive to students as well as other geologists. This was proposed 10 years ago and considered a good idea by Peter Allen and Chris Green but unfortunately it foundered due to financial restraints.
- Produce the condensed version as a graphics-based electronic product for incorporation into the field data capture system.
- Develop dictionaries and glossary as a downloadable data product for licencing and sale, enhancing the product that is currently available.

A system must also be devised and put in place to ensure that the RCS (and indeed all BGS Geostandards) becomes a true corporate standard (i.e. used by all staff in all projects), instead of being used by a subset of staff in some projects, as is currently the case. When it was first produced it was agreed that conformity with the RCS would be part of the BGS report management system but this was never carried out.

While the availability of the RCS as downloadable pdf files is important, the revised scheme should be promoted and made easily available in-house to all scientific staff as printed documents following the form of the *Notes for Authors*. BGS staff may respond more readily to the peer reviewed printed page than to downloadable digital files.

6 Proposals for revising the BGS Rock Classification Scheme

The RCS has been in existence for 10 years but there is still some uncertainty within many parts of BGS about the role of the RCS, and other BGS Geostandards such as the Lexicon. The introduction to all the reports needs a section clarifying this situation, stating clearly that the RCS is to be used for classifying single lithology, hand specimen-sized or smaller samples. The rock types approved by the scheme are then used as the building blocks for Lexicon entries and map polygon definitions, which are commonly formed by combining several RCS-approved rock types.

Classifying rock unit (or heterolithic) lithologies has always been a persistent bugbear of the RCS and other BGS dictionaries. This is beyond the scope of the RCS revision but a coherent, scientifically documented scheme for doing that is sorely needed and should be a high priority for the future.

6.1 REVIEW AND PROPOSED REVISIONS TO RCS VOLUME I: IGNEOUS ROCKS

A thorough review of the existing RCS Volume 1 has been carried out, and numerous potential improvements have been noted, as annotations, on a hard copy of the report. The recently published second edition of the IUGS recommendations for igneous rock classification (Le Maitre et al. 2002) has also been reviewed thoroughly, and changes to the original edition have been noted. On the basis of these two reviews, and on the basis of feedback received and discussions held within BGS since the RCS was first published, it is proposed that RCS Volume I be improved and updated in the course of a thorough revision. The main proposed elements of the revision are:

- make all necessary changes to the text and figures to bring the classification into line with Le Maitre et al. (2002).
- Where appropriate, add sections of text or change the wording of text to improve its clarity.
- Streamline text where there is unnecessary repetition (e.g. sections dealing with colour index).
- In the sections dealing with coarse-grained and fine-grained igneous rocks, delete text that essentially repeats information that is obvious from the classification figures.
- Set out the changes suggested following the ‘MacGregor translations’ and introduce the terms ‘macrophyric’ and ‘microphyric’, as used in the new MacGregor translations.
- Move all ‘sedimentary’ root names in the volcaniclastic section to the sedimentary scheme.
- Modify some figures to reflect changes discussed and agreed since the RCS was published.
- Discuss whether we should persist with the BGS grain size scheme and the system of using hyphens in rock names (as neither IUGS nor any other geological survey organisation has adopted the BGS approach); if it agreed to change these, make necessary changes to the text and figures.

- Make numerous editorial changes to correct errors and typos.
- Correct all knock-on changes to the text, figures and appendix incurred by the changes noted above.
- Add a glossary of approved rock names and other terms associated with rock classification, with their definitions.
- Add an appendix with RCS translations of rock names commonly used in the past but now considered obsolete, using the obsolete names table in computer dictionary table RCSV3 as a guide

6.2 REVIEW AND PROPOSED REVISIONS TO RCS VOLUME 2: METAMORPHIC ROCKS

6.2.1 Introduction

The first BGS rock classification scheme for metamorphic rocks was published in 1999. This scheme was tested and used by BGS geologists in the UK and overseas but also by a large number of users outside of BGS. The huge numbers of downloads proved on one hand the acceptance of this scheme and on the other hand the necessity of a consistent classification scheme that was lacking at that time. Meanwhile, the IUGS Subcommission on the Systematics of Metamorphic Rocks (SCMR) has published a series of Recommendations that make an update of the BGS classification scheme necessary.

Recommendations by SCMR (http://www.bgs.ac.uk/SCMR/):

Schmid, R, Fettes, D, Harte, B, Davis, E, Desmons, J, Meyer-Marsilius, H-J and Siivola, J: A systematic nomenclature for metamorphic rocks: **1. How to name a metamorphic rock**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 01.05.2004.

Smulikowski, W, Desmons, J, Harte, B, Sassi, F P and Schmid, R: A systematic nomenclature for metamorphic rocks: **2. Types, grade and facies**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 01.05.2004.

Brodie, K H, Fettes, D, Harte, B and Schmid, R: Towards a unified nomenclature in metamorphic petrology: **3. Structural terms including fault rocks**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 30.11.2004.

Desmons, J and Smulikowski, W: A systematic nomenclature for metamorphic rocks: **4. High P/T metamorphic rocks**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 01.05.2004.

Árkai, P, Sassi, F P and Desmons, J: A systematic nomenclature for metamorphic rocks: **5. Very-low grade to low-grade metamorphic rocks**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 01.05.2004.

Wimmenauer, W, and Bryhni, I: Towards a unified nomenclature of metamorphism: **6 Migmatites and related rocks**. A proposal on behalf of the IUGS Subcommission on the Systematics of Metamorphic Rocks. Provisional recommendations, web version of 31.07.2002.

Rosen, O M, Desmons, J. and Fettes, D: Towards a unified nomenclature of metamorphism: **7 Metacarbonate and related rocks**. A proposal on behalf of the IUGS Subcommission on the Systematics of Metamorphic Rocks. Provisional recommendations, web version of 01.05.2004.

Coutinho, J M V, Kräutner, H G, Sassi, F, Schmid R and Sen, S: A systematic nomenclature for metamorphic rocks: **8. Amphibolite and granulite**. Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks. Recommendations, web version of 01.05.2004.

Stöffler, D. and Grieve, R.A.F: Towards a unified nomenclature of metamorphism: **11. Impactites**. A proposal on behalf of the IUGS Subcommission on the Systematics of Metamorphic Rocks. Provisional recommendations, web version of 30.06.2003.

Recommendations for metasomatic rocks and contact metamorphic rocks are in preparation. A classification scheme for quartzofeldsphatic rocks of medium metamorphic grade is neither available nor announced by SCMR. Some guidelines for such rocks can be found in the first paper *How to name a metamorphic rock* (Schmid et al. 2004).

A recent internet enquiry showed that most surveys, universities and private institutions either refer to the BGS scheme or to the IUGS recommendations. The Geological Survey of Western Australia published a rock classification scheme (Tyler et al. 2004) that is based on two approaches:

I) the protolith is known: use of the prefix *meta*

II) the protolith is unknown: use of descriptive structural root names (e.g. *gneiss*) with qualifiers.

This paper is not very detailed; it gives no definitions or even a complete list of all terms allowed in their classification scheme.

The Canadian Geological Survey chose another approach to classification (Struik et al., 2002). Their system is multi-hierarchical, using composition, texture and fabric as the basis for classification. The rock classification follows mainly the BGS scheme (it includes also sedimentary and igneous rocks) but a definition of the terms is lacking.

Classical approaches such as purely compositional classification schemes of metamorphic rocks (e.g. Winkler 1979) were not broadly accepted for two reasons:

- they normally require additional laboratory studies, i.e. they are not practical for use in the field
- they do not give any guidance on the use of fabric-related terms.

6.2.2 Revision of the BGS classification scheme

This section follows the structure of the BGS classification scheme and addresses those parts that need an update or/and major changes.

6.2.2.1 Definition of metamorphism

The definition should have a more “scientific” approach; metamorphism is a solid stage change of a rock, resulting from chemical and/or physical changes of the minerals. This should be considered also for the subdivision of the types of metamorphism. We can distinguish broadly isochemical or non-isochemical metamorphic rocks (the latter are summarized as metasomatic rocks) and the physical changes are caused by three factors:

- temperature

- pressure
- stress.

Individual factors can dominate (e.g. temperature for contact metamorphism), in other cases all factors are recorded in the resulting type of metamorphism (e.g. orogenic metamorphism). This approach is more focussed on the rock than the geographical approach recommended by IUGS, which distinguishes between regional and local types of metamorphism.

6.2.2.2 METAMORPHIC ROCK NOMENCLATURE

This section of the RCS has to be slightly modified according to the main changes made in the following sections.

6.2.2.3 SEDIMENTARY PROTOLITH

The usage of the terms psammite, semipelite and pelite for metamorphic rocks is no longer acceptable (Schmid, 2004). In English literature these terms are used for mica-rich quartzofeldspathic metamorphic rocks, whereas in continental Europe these terms are used for sedimentary rocks. The terms are based on a modal classification that may cause other problems, since the modal composition can change due to metamorphic reactions. As an example, the reaction chlorite + muscovite = garnet + biotite + quartz is very characteristic for the first formation of garnet at increasing temperature. The newly crystallised quartz will change the modal composition when passing the isograde for that reaction.

Using the prefix *meta* for these three rock types is also unsatisfactory, since the term metapelite has been used for a broad variety of alumosilicate-bearing metasedimentary rocks, therefore these terms should be replaced by metamudstone, metasandstone, etc.

6.2.2.4 VOLCANICLASTIC ROCK PROTOLITH

This section needs no changes but attention should be paid to Table 2 if any grain size changes are made in the classification of volcaniclastic rocks.

6.2.2.5 IGNEOUS PROTOLITH

In general, there are no changes necessary. It should be discussed if, for a better understanding, some root names for meta-ultramafic rocks have to be changed. The name “hornblende-rock” or “pyroxene-rock” may not be directly associated to a metamorphic rock, especially for students and scientists that are not specialised in the field of metamorphic rocks. Terms like “meta-hornblendite” can only be used for a metamorphosed igneous ‘hornblendeite’ hence the usage of qualifiers like “hornblende-rich meta-ultramafic-rocks” could be used, taking into account that such long terms have not to be given very often due to the scarcity of such rocks.

6.2.2.6 UNKNOWN PROTOLITH

No changes necessary.

6.2.2.7 DISLOCATION METAMORPHIC ROCKS

The actual classification of dislocation metamorphic rocks follows generally the IUGS recommendations. The name previously used for the whole group “mechanically broken and reconstituted rocks” is misleading, some of these rocks were never “broken”, but specifically those rocks that were broken are not metamorphic rocks in a strict sense. Rocks without primary cohesion (fault-breccia, fault-gouge) will in the future be removed from the **Metamorphic** scheme and considered in the **Discontinuities** scheme. Mylonitic rocks will be covered by both the Discontinuities and the Metamorphic scheme. The remaining rocks within this group should be summarized under the name “dislocation metamorphic rocks”.

The group of cataclastic rocks is transitional between metamorphic rocks and mechanically broken rocks, strongly depending on mineral composition and strain rates. Other classification schemes define cataclastic rocks as rocks with a primary cohesion where cataclasis prevails over dynamic recrystallisation (Heitzmann 1985). The current definition of cataclasites as “unfoliated rocks with primary cohesion” needs to be reconsidered. Cataclasites often show a planar fabric resulting from layers of different grain sizes due to strain partitioning. Pseudotachylites are an extreme end member of cataclastic rocks.

Blastomylonites are in some classifications regarded as a special group. Low strain rates and high fluid flux can result in grain growth. The grain size of blastomylonites can exceed the average grain size in adjacent, less deformed rocks. The last sentence in section 7.3 is wrong: Ribbon quartz is usually not a common feature in blastomylonites!

6.2.2.8 Metasomatic rocks

The original section about metasomatic rocks had recognised shortcomings and needs considerable revision. The difficulties for a classification arise from the disequilibria of those rocks, which make it nearly impossible to classify them with respect to diagnostic minerals. An extensive literature about skarns exists (e.g. Burt 1977, Meinert 1992) but the best overview is published online by Larry Meinert:

http://www.wsu.edu:8080/~meinert/aboutskarn.html#Definitions

For rodingites the paper by Hall and Ahmed (1984) gives a reasonable definition, but any further subdivision has not been undertaken yet.

Fenites have mostly been studied together with carbonatites, definitions are given in McKie (1966), Wooley (1969) and Le Bas (1977).

Greisen is defined as a granoblastic aggregate of quartz and muscovite or lepidolite with accessory amounts of topaz, tourmaline and fluorite, formed as an alteration product of granites (Best 1982). They belong to the group of hydrothermally altered rocks and form an important source of tin and tungsten minerals. Therefore, most of the literature can be found in papers about the ore mineralogy of these rocks. A short article was published by M.T. Einaudi in the *McGraw-Hill Encyclopedia of Science & Technology Online*: (http://www.accessscience.com/Encyclopedia/3/30/Est_300100_frameset.html?doi)

6.2.2.9 Special case metamorphic rocks

This section of the original report, which covered everything that had not been included anywhere else, would benefit from better organisation. It can be split in two chapters, one dealing with High P/T metamorphic rocks, using the recommendations No. 4 and 8 by the SCMR (Desmonds and Smulikowski 2004, Coutinho et al. 2004) and a chapter about migmatites and related rocks which are covered by SCMR recommendation No. 6 (Wimmenauer and Bryhni 2002). Recommendation No. 4 also considers the terms ‘blueschist’ and ‘whiteschist’, giving them appropriate names.

The recommendation covering migmatites is a preliminary proposal that contains numerous useful definitions, but not a practical classification. Some terms are purely genetic and were rejected for this reason in the present classification scheme (e.g. venite, arterite). The new classification scheme should not re-introduce them. The BGS scheme however, is only applicable as long as the protolith (paleosome) can be clearly identified, i.e. for metatectic rocks.

It does also not consider the volume ratio between paleosome and neosome. For metamorphic rocks with high proportions of neosome (diatexites) the BGS scheme becomes inapplicable. Some additional root names and/or qualifiers are necessary to classify such rocks.

The qualifier migmatitic is not very specific; the full range of structural qualifiers according to Mehnert (1968) should be used, not only *stromatic* and *agmatitic*. For example, the name *dityonitic* **orthogneiss** is more instructive than *migmatitic* orthogneiss since they include a definition of the relation between leucosome and paleosome.

For slate and phyllite a section “Very low-grade Metamorphic Rocks” should be added (see below).

The section about contact metamorphic rocks has to be slightly modified. Contact metamorphic rocks are characterized by a number of diagnostic low-P/high-T minerals, therefore mineral qualifiers together with the root name **hornfels** are sufficient for a classification of many contact metamorphic rocks. In practice however, there are numerous examples where this root name is not appropriate, e.g. when the protolith already had a strong fissility. Many examples of slates and schists are known which underwent a contact metamorphic overprint. The result is still a slaty or schistose rock, overgrown by typical low-P/high-T minerals (*Knotenschiefer, Fruchtschiefer*). The qualifier “hornfelsed” is somewhat odd because the resulting metamorphic rock will not have fabric attributes resembling a hornfels.

6.2.2.10 QUALIFIERS

The section has to be modified according to changes in other sections. The section “Textural qualifiers” could be transformed into a glossary and added as an appendix. The definitions of the qualifiers

- *gneissose,*
- *hornfelsed,*
- *lineated,*
- *migmatitic,*
- *mylonitic*

need to be carefully corrected/rewritten.

6.2.2.11 TABLES AND FIGURES

The following figures have to be changed according to the suggested changes in the text:

Fig. 2: add field of diagenesis

Fig. 3: modify according to changes in the text (e.g. pelite, semipelite, psammite)

Figs. 4, 5, 6: have to be renamed according to changes in the text

Some additional figures could also help to clarify terms, similar to Fig. 4:

A figure showing factors of metamorphism and resulting metamorphism types: Figure 4 below

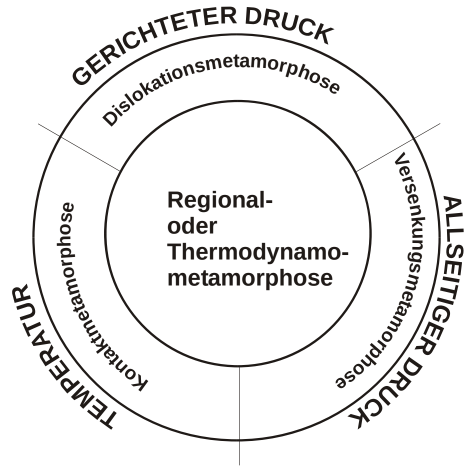

Fig. 4: Major types of metamorphism resulting from stress, temperature and pressure (Bauer 2002).

A figure with protoliths and changes due to different metamorphism types/grades:

	Ausgangsgestein						
	Magmatite			Sedimentite			
Metamorphosetyp	sauer	basisch	ultrabasisch	Sandstein	Ton, tonige Klastika	Mergel	Kalkstein
Kontaktmetamorphose	keine Veränderung		Serpentinit	Quarzit	Frucht-, Garben-, Knotenschiefer, Hornfels	Kalksilikat-Hornfels	Marmor
Regionalmetamorphose: schwach	↓	Grünschiefer	Serpentinit	↑	Phyllit	Kalksilikat-Phyllit	↑
Regionalmetamorphose: mittel	Orthogneis	(Ortho-) Amphibolit	Olivinfels u.ä.	Quarzit	Paragneis, Glimmerschiefer	(Para-) Amphibolit, Kalksilikatfels	Marmor
Regionalmetamorphose: stark oder mehrfach	Granulit	Pyroxen-granulit/ Eklogit	Granat-peridotit	↓	Granulit	Pyroxen-granulit/ Eklogit	↓

Fig. 5: Matrix of metamorphism types (left) and protoliths (upper row) resulting in different metamorphic rocks (example from Bauer 2002) to be translated into English.

6.2.3 Additions to the present classification scheme

6.2.3.1 Very low-grade metamorphic rocks

The boundary between diagenesis and very low-grade metamorphism is a gradual change in most rocks composed of silicate minerals. Different criteria have been used to define the boundary diagenesis/metamorphism (e.g. first occurrence of lawsonite, coal rank scales, illite 'crystallinity') but the main weakness of these methods are that they are not applicable in the field and they are restricted to certain rock types. For mafic volcanic rocks the first occurrence of zeolites is indicative for very low-grade metamorphic rocks (see Arkai et al. 2004). Unfortunately, for 'normal' siliciclastic rocks a technical method has to be applied. The anchizone or very low-grade metamorphism is defined by a Kübler Index (KI), measured on the < 2μ fraction of clay-rich clastic rocks, showing KI values between 0.55 and 0.20 $\Delta°2\theta$. In orogens, mudstones are mostly transformed into slates around 0.42 $\Delta°2\theta$. Slate, however, has been defined in the present BGS scheme as a root name for metamorphic rocks with a strong fissility, but in fact these rocks often yield KI values greater than 0.42 $\Delta°2\theta$.

The problem can be solved by:

- discussing slates as a 'transitional' rock type which might be either a metamorphic or a sedimentary rock with a strong fissility, or
- introducing a field-based differentiation between slate (sedimentary rock) and phyllite (metamorphic rock).

Both terms are defined in the SCMR recommendations No. 5 (Arkai et al. 2004) which can be used as a guideline for classifying these rocks. Generally, the low-grade overprint allows the use of the prefix *meta* in combination with the protolith name. Several rock types do not show any mineralogical change at that stage of metamorphism.

6.2.3.2 SPECIAL TYPES OF METAMORPHIC ROCKS

Some types of metamorphic rocks are rare or rarely preserved, nevertheless they often tell interesting stories and should be briefly mentioned. They are the products of:

- impact metamorphism
- pyrometamorphism
- combustion metamorphism
- lightning metamorphism
- hot slab metamorphism.

Another section should be included to mention metamorphic changes in rocks composed of non-silicate minerals, e.g. coal, evaporitic rocks. Their field of metamorphism starts at significantly lower temperatures and pressures. This section can also be added to the section about metamorphic rocks with sedimentary protoliths.

6.2.3.3 CHARNOCKITES

The classification of charnockites was a topic of great difficulty and discussion during the production of the RCS. The decision at that time was that rocks with charnockitic characteristics were not included in the metamorphic scheme, but were denoted using qualifiers with common root names for igneous rocks. The root of the problem is that rocks commonly referred to as charnockites can either be of igneous or metamorphic origin and in many cases it is not possible to decide which origin is correct, especially in small outcrops.

The qualifier *charnockitic* in combination with gneiss is not acceptable because, as a common feature, gneisses lose their foliation during the recrystallisation process. On the other hand, the term *charnockitic* **granofels** can be misleading because of a lack of criteria to distinguish metamorphic from igneous charnockites. The terms arrested charnockite or incipient charnockite have been introduced for charnockites of metamorphic origin (Hansen et al. 1987).

The status of charnockitic rocks needs to be reconsidered, particularly in view of the greater in-house expertise on these types of rocks. A possible solution would be to place charnockites and related rocks either as a separate (transitional) group between igneous and metamorphic rocks or to use *charnockitic* as a qualifier in all cases where the origin is uncertain.

6.2.3.4 Glossary

A glossary with four categories would be useful:

a) Root names
b) Qualifiers
c) Restricted rock names
d) Obsolete rock names (with recommended replacements).

Such a glossary would be an ideal reference to update databases or to "translate" metamorphic rock names from old maps, explanatory volume and literature. This glossary should also cite the original source of a term, this can be copied from geological dictionaries.

6.2.4 Summary

The present BGS classification scheme for metamorphic rocks has been widely accepted by geoscientists in recent years. It obviously had a strong influence on the recommendations by IUGS-SCMR, therefore only minor changes are necessary.

- An update of existing sections and addition of some necessary amendments
- Removal of terms only used in English literature
- Discussion of the "charnockite problem"
- Addition of a glossary

REVIEW AND PROPOSED REVISIONS TO RCS VOLUME 3: SEDIMENTS AND SEDIMENTARY ROCKS.

6.2.5 Introduction

The BGS rock classification scheme for sediments and sedimentary rocks (Hallsworth and Knox 1999) was published in 1999 and has been accepted as the corporate standard in BGS for the description of both lithified and unlithified (i.e. superficial) sedimentary units. The scheme is not essentially new but sets out to rationalize and integrate a number of widely used, existing classification schemes. The classification has been well received by outside bodies, notably the US and Canadian national geological surveys. Like all successful classification schemes it has a simple structure that has been shown to work. Despite this acceptance, however, it is perhaps still not as widely applied within BGS as might be expected. This appears to be largely a consequence of lethargy by staff rather than a fundamental disagreement with the scheme and its aims, as there have been few critical comments from those BGS staff that actually use the scheme.

6.2.6 The Classification scheme

There seems to be very little dispute amongst BGS staff that a corporate Rock Classification Scheme is necessary for disseminating geological data through, and outside, BGS. In contrast to the igneous and metamorphic rock groups it has not been possible to follow closely schemes laid down by the International community. *There is no such comparable international scheme available or in preparation for sedimentary rocks and sediments*, hence the need for BGS to develop its own scheme. In this respect, BGS is well ahead of the field and staff should recognise that our published scheme is now likely to form the basis of any international scheme subsequently developed. There appears to be a surprising reluctance among staff to accept that our scheme has been a notable success and ensure it is used and further developed. There are a number of possible reasons for this reluctance.

- There is always a general resistance to change amongst BGS staff and a reluctance to accept that any scheme developed in house, no matter how successful outside the organisation, is really ‘up to the job’.
- Some clients require the application of their own in-house rock classification schemes – perhaps BGS should be more actively pushing the advantages of our scheme.
- Some areas of geological science, notably in the engineering sector, have developed their own schemes to a British and/or European Standard and require all their data to be described and classified according to such schemes. Such schemes are commonly difficult to reconcile with other geological rock classification schemes. There is very little likelihood, despite the many inconsistencies they contain, that the engineering geological community will move away from their existing scheme.
- There is a tendency (understandable in some cases) among geologists to develop and adapt existing classification schemes to make them more applicable to the needs of a current project.
- At times there is a client-driven need to provide definitions that go against the recommendations of the RCS scheme e.g. Merriman et.al. http://www.mineralsuk.com/britmin/cr03281n.pdf

6.2.7 Revision of the BGS classification scheme

The remit of the Sedimentary RCS project was ‘*to present a classification for lithified and unlithified sediments that is logical, systematic, hierarchical and uses clearly defined, unambiguous names*’.

The classification has generally been well received and no fundamental revision is envisaged. However, there are some minor inconsistencies in the text and diagrams that need correcting.

Any revision of the scheme, however, should give consideration to the following points: -

Since the publication of the scheme, BGS has commissioned Brian King of **Georeference Online Ltd** http://www.georeferenceonline.com/ to compile formal definitions of the principal rock terms used in the sedimentary classification scheme. In order to facilitate this process it was necessary to produce strict definitions of some terms used in the scheme.

e.g. **grain** for the units of most clastic rocks with sizes 2mm to 0.032mm.

particle for the units of most clastic rocks with sizes <0.032mm.

clast for the units of most clastic rocks with sizes above 2mm.

It would be advantageous to include these definitions as an appendix in any revision of the scheme, for example:

coal	185	Organic rock	Lithified heterogeneous brown/black mixture of a wide range of plant debris, sometimes identifiable. 60 to >90% carbon, dry, ash-free. Volatiles <14 to 46%. Wide range of carbonisation.
coal shale	171		Sedimentary rock, particles >50% or predominantly mud-grade, <0.032mm. Associated with coal seams & commonly containing a wide range of carbonaceous plant debris. A shale.

coarse lime-sand	128	Carbonate rock	Sediment with components >50% calcite/aragonite. Components >50% or predominantly sand-grade, 0.032 to 2mm, (most 0.5 to 1mm).
coarse silicate-sand	162	Clastic sediment	Siliciclastic arenaceous sediment with >50vol% clasts from pre-existing siliceous rocks. Clasts >50% or predominantly sand-grade, 0.032 to 2mm, (most 0.5 to 1mm).
coarse silicate-sandstone	170	Clastic rock	Siliciclastic arenaceous sedimentary rock with >50vol% clasts from pre-existing siliceous rocks. Clasts >50% or predominantly sand-grade, 0.032 to 2mm, (most 0.5 to 1mm).
coarse, crystalline limestone	118	Carbonate rock	Sedimentary rock composed entirely of contiguous crystals >50% calcite/aragonite. Ave. crystal size between 2 & 16mm.
cobble gravel	185	Clastic sediment	Siliciclastic sediment, with >50vol% clasts from pre-existing siliceous rocks. Clasts >50% or predominantly gravel-grade, >2.0mm, 5-20% cobble-grade 64 to 256mm. Composition not defined

There is also a need to incorporate an **Index** of approved terms appearing in the Classification to facilitate its use by staff.

BGS continues to develop other schemes (both for coding and classification) for heterolithic lithologies and project-based programmes (e.g. Cooper et al., 2005). Such schemes should be seen as adjuncts to the corporate RCS scheme and should be integrated as far as possible with the RCS.

7 A programme for revision and ongoing maintenance of the RCS

The RCS is in urgent need of correction and updating. In regards to the basic technical changes outlined in section 4, this can be completed in FY 2006-7. This will involve the authors of the scheme and a small amount of time for a small working group of knowledgeable individuals within BGS and possibly outside to review the proposed changes and finalise any policy issues that need to be discussed and agreed.

If an enhancement of the scheme (i.e. ‘option b’, Section 5) is approved more resources will be required both for the authors and for support staff such as the those in the Drawing Office, book production, web designers etc. This will inevitably take more time but could be phased over a longer period than the technical revision. It would, however, be useful to know at an early stage if this is going to take place, as it will influence the way the technical revision is done and could save on likely duplication in production of diagrams etc. The amount of staff time required depends on the extent of enhancements to be made.

Changes to the RCS will have a knock-on effect in several areas of BGS, particularly the RCS dictionaries that underpin many databases. Once the schemes have been revised they will need to be incorporated into the dictionary tables. The population of databases regularly produces the need for new combinations of rock names and qualifiers and these need to be checked and approved by RCS experts. It is suggested that these are all incorporated into an annual update of the RCS, that all main users are notified of these updates, and a log of changes is maintained. A small amount of staff time is required every year for RCS experts to fulfil this function

It is further suggested that every five years a review panel assesses the current state of the schemes and annual updates, and makes recommendations about the need for an update and re-release of the RCS.

Appendix 1

RCS Web Statistics

Resource	Date		Period	Total	Igneous		Sedimentary		Metatmorphic		Superficials	
Filename	From	To	Days	Downloads	Downloads	Position	Downloads	Position	Downloads	Position	Downloads	Position
(none)	12-Feb-00	10-Mar-00	28									
(none)	11-Mar-00	7-Apr-00	28									
(none)	8-Apr-00	5-May-00	28									
(none)	6-May-00	2-Jun-00	28									
(none)	3-Jun-00	30-Jun-00	28									
inter0600	1-Jul-00	1-Aug-00	31	389	23	10	19	14			14	18
inter0700	1-Aug-00	26-Aug-00	26	282	26	7	14	13	16	11	9	19
inter0800	27-Aug-00	23-Sep-00	27	290	25	10	15	14	13	16	32	5
inter0900	23-Sep-00	21-Oct-00	29	460	27	7	22	11	17	13	28	5
inter1000	22-Oct-00	18-Nov-00	28	680	28	8	28	9	29	5	26	10
inter1100	19-Nov-00	16-Dec-00	28	890	43	5	45	4	39	6	39	7
inter1200	17-Dec-00	13-Jan-01	28	1129	36	3	27	5	26	6	26	7
inter0101	14-Jan-01	20-Feb-01	28	350	36	4	34	6	28	11	32	8
inter0201	11-Feb-01	10-Mar-01	28	483	76	3	59	5	53	6	46	7
inter0301	11-Mar-01	7-Apr-01	28	245	46	3	35	7	40	5	29	12
inter0401	8-Apr-01	5-May-01	28	807	36	8	30	11	28	13	29	12
inter0501	6-May-01	2-Jun-01	28	617	35	7	26	12	20	19	27	11
inter0601	3-Jun-01	30-Jun-01	28	745	44	6	38	8	31	11	53	3
inter0701	1-Jul-01	28-Jul-01	28	1253	58	3	45	7	34	10	47	5
inter0801	29-Jul-01	25-Aug-01	28	353	30	8	33	7	20	16	26	10
inter0901	26-Aug-01	22-Sep-01	28	733	48	5	56	3	43	8	44	7
inter1001	23-Sep-01	20-Oct-01	28	846	74	10	64	13	58	18	47	15
inter1101	21-Oct-01	17-Nov-01	28	1209	125	8	85	16	83	18	58	27
inter1201	18-Nov-01	15-Dec-01	28	2003	115	9	93	13	80	16	81	15
inter0102	16-Dec-01	12-Jan-02	28	643	65	7	60	8	49	13	45	14
inter0202	13-Jan-02	9-Feb-02	28	1396	136	5	116	6	92	10	93	9
inter0302	10-Feb-02	9-Mar-02	28	1707	107	6	90	9	68	17	63	18
inter0402	10-Mar-02	6-Apr-02	28	1306	116	5	93	6	79	8	65	13
inter0502	7-Apr-02	4-May-02	28	1614	132	5	132	6	83	12	89	10
inter0602	5-May-02	1-Jun-02	28	891	98	5	89	7	68	11	62	16

inter0702	2-Jun-02	29-Jun-02	28	1809	89	6	79	8	62	16	73	12
inter0802	30-Jun-02	27-Jul-02	28	1080	92	4	92	5	66	13	73	11
inter0902	28-Jul-02	24-Aug-02	28	1079	79	10	73	12	53	18	68	13
inter1002	25-Aug-02	21-Sep-02	28	1031	99	4	89	6	62	14	57	15
inter1102	22-Sep-02	19-Oct-02	28	1387	166	2	134	5	120	8	99	10
inter1202	20-Oct-02	16-Nov-02	28	1677	218	2	157	5	136	7	142	6
inter1302	17-Nov-02	14-Dec-02	28	1564	139	4	103	9	103	8	69	16
inter0103	15-Dec-02	11-Jan-03	28	1508	81	7	49	17	51	16	43	21
inter0203	12-Jan-03	8-Feb-03	28	5053	144	3	98	7	76	13	67	15
inter0303	9-Feb-03	8-Mar-03	28	5649	135	3	105	6	76	13	68	18
inter0403	9-Mar-03	5-Apr-03	28	5234	123	4	116	6	72	13	64	19
inter0503	6-Apr-03	3-May-03	28	5943	145	3	101	8	83	11	83	12
inter0603	4-May-03	31-May-03	28	6321	122	3	91	8	77	12	69	15
inter0703	1-Jun-03	28-Jun-03	28	5212	135	3	118	4	80	9	75	13
inter0803	29-Jun-03	26-Jul-03	28	7698	97	3	79	7	71	11	68	12
inter0903	27-Jul-03	23-Aug-03	28	7447	105	4	85	8	67	22	58	29
inter1003	24-Aug-03	20-Sep-03	28	7143	115	3	80	14	70	18	79	15
inter1103	21-Sep-03	18-Oct-03	28	7048	148	3	111	7	91	13	87	16
inter1203	19-Oct-03	15-Nov-03	27	9341	156	4	118	7	102	9	96	15
inter1403	15-Nov-03	13-Dec-03	29	7035	140	3	92	12	80	17	76	18
inter1503-04	14-Dec-03	10-Jan-04	28	3321	93	3	68	8	68	7	58	14
inter0104	11-Jan-04	7-Feb-04	28	7559	161	2	111	5	101	8	87	13
inter0204	8-Feb-04	6-Mar-04	28	8777	165	3	132	14	94	14	101	12
inter0304	7-Mar-04	3-Apr-04	28	7438	180	3	131	4	100	9	89	17
inter0404	4-Apr-04	1-May-04	28	10417	250	1	222	2	164	4	112	7
inter0504	2-May-04	29-May-04	28	8808	229	2	229	1	143	5	110	10
inter0604	30-May-04	26-Jun-04	28	9706	231	1	203	2	149	4	82	14
inter0704	27-Jun-04	24-Jul-04	28	8407	190	2	175	3	124	4	86	11
inter0804	25-Jul-04	21-Aug-04	28	8458	192	1	192	2	140	4	83	10
inter0904	22-Aug-04	18-Sep-04	28	7951	260	1	215	2	141	5	92	10
inter1004	19-Sep-04	16-Oct-04	28	9414	257	2	184	3	142	7	77	24
inter1104	17-Oct-04	13-Nov-04	28	7151	251	2	213	3	151	6	94	17
inter1204	14-Nov-04	11-Dec-04	28	10297	243	2	206	3	138	7	82	21
inter1304	12-Dec-04	8-Jan-05	28	7214	145	4	158	3	84	10	56	24
inter0105	9-Jan-05	5-Feb-05	28	10849	230	3	188	4	121	8	78	23
inter0205	6-Feb-05	4-Mar-05	27	9964	278	3	228	4	135	9	111	16
inter0305	5-Mar-05	2-Apr-05	29	10628	254	2	228	3	127	12	101	19
inter0405	3-Apr-05	30-Apr-05	28	9347	272	2	249	3	138	9	93	22
inter0505	1-May-05	28-May-05	28	10340	243	5	334	3	124	12	79	32
inter0605	29-May-05	25-Jun-05	28	9879	244	3	361	1	144	7	108	11
inter0705	26-Jun-05	23-Jul-05	28	10374	194	3	342	1	100	13	70	25
inter0805	24-Jul-05	20-Aug-05	28	8361	204	3	238	2	118	10	109	12

inter0905	21-Aug-05	17-Sep-05	28	10794	231	5	276	3	105	18	83	27
inter1005	18-Sep-05	15-Oct-05	28	11563	296	4	550	1	126	14	133	11
inter1105	16-Oct-05	12-Nov-05	28	12103	259	5	484	1	131	16	128	17
inter1205	13-Nov-05	10-Dec-05	28	48571	272	5	417	1	140	13	139	14
inter1305	11-Dec-05	7-Jan-06	28	13816	210	4	342	2	129	10	119	12
inter0106	8-Jan-06	4-Feb-06	28	14355	267	4	418	3	126	15	117	19
inter0206a+b	5-Feb-06	4-Mar-06	28	37445	290	3	469	3	165	9	133	14

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