Geoscientist Feature March 2008 vol. 18: p.22-24

Golden Rum! Understanding the Forbidden Isle

Rum, Inner Hebrides, was virtually closed for the first half of the 20th Century and was known as the 'Forbidden Island'. However, since becoming a National Nature Reserve the island's spectacular landscape has become a natural research laboratory. Kathryn Goodenough, Henry Emeleus, Dougal Jerram and Val Troll* report.

In May 2007, the Volcanic and Magmatic Studies Group (VMSG - Kathryn Goodenough, Henry Emeleus, Dougal Jerram and Val Troll) organised an Arthur Holmes field meeting entitled "Golden Rum", to celebrate that research. Out of that visit grew this report.

Early visitors

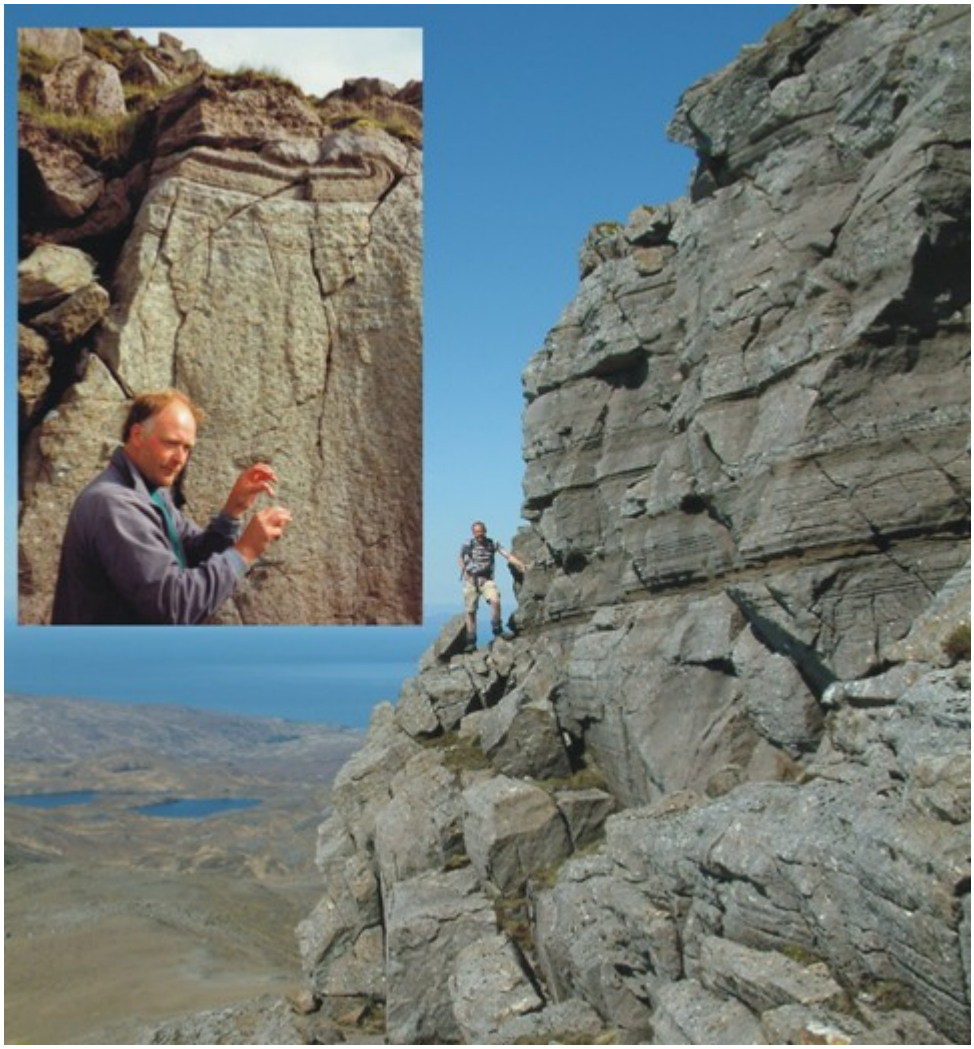
Neolithic people came to Rum to quarry 'bloodstone' (heliotrope, a variety of chalcedony found within the lavas) for tools, but the first modern geologist to visit was John MacCulloch, who came in the early 19th Century while travelling around the Western Isles. He produced a map (Fig. 1) delineating some of the main geological features of Rum, including 'red sandstone' in the north of the island, 'syenite' in the west, 'augit rock' forming the central hills, and 'basalt and amygdaloid'. The red sandstones are now known to be Neoproterozoic (Torridon Group). MacCulloch's 'syenite' and 'augit rock' respectively represent the Western Granite and the mafic/ultramafic layered intrusions, two of the main components of the Palaeogene-age Rum Central Complex. The 'basalt and amygdaloid' can be recognised as outcrops of Palaeogene lavas in Western Rum.

Following MacCulloch, a few other 19th Century geologists visited, including Prof. John Wesley Judd and Sir Archibald Geikie. Judd suggested that the intrusive rocks of Rum represented the eroded roots of ancient volcanoes. Throughout the 19th Century, the island changed hands many times, but in 1888 was finally sold to English industrialist John Bullough. The Bullough family kept the island as a private shooting estate for the next 70 years; although they did allow scientists to visit when the guns were silent. Alfred Harker was one, and in 1908 he produced a memoir for the Geological Survey on the Small Isles of Inverness-shire, together with the first six-inch maps of Rum and nearby islands. His maps, much more detailed than any that had gone before, showed extensive areas of breccias and felsic igneous rocks around the margins of the mafic intrusions in the Rum Central Complex.

Recognition of Rum's potential in understanding volcanic processes came towards the end of WW2, when Sir Edward Battersby Bailey and James Ernest Richey paid a visit. In a 1945 paper, Bailey showed that Rum's igneous centre was bounded by a steep-sided ring fault, and that rocks exposed within this fault included basement gneisses, uplifted by several kilometres. He also interpreted some of the breccias within the complex as explosion breccias. Bailey had identified some of the main features of a caldera volcano.

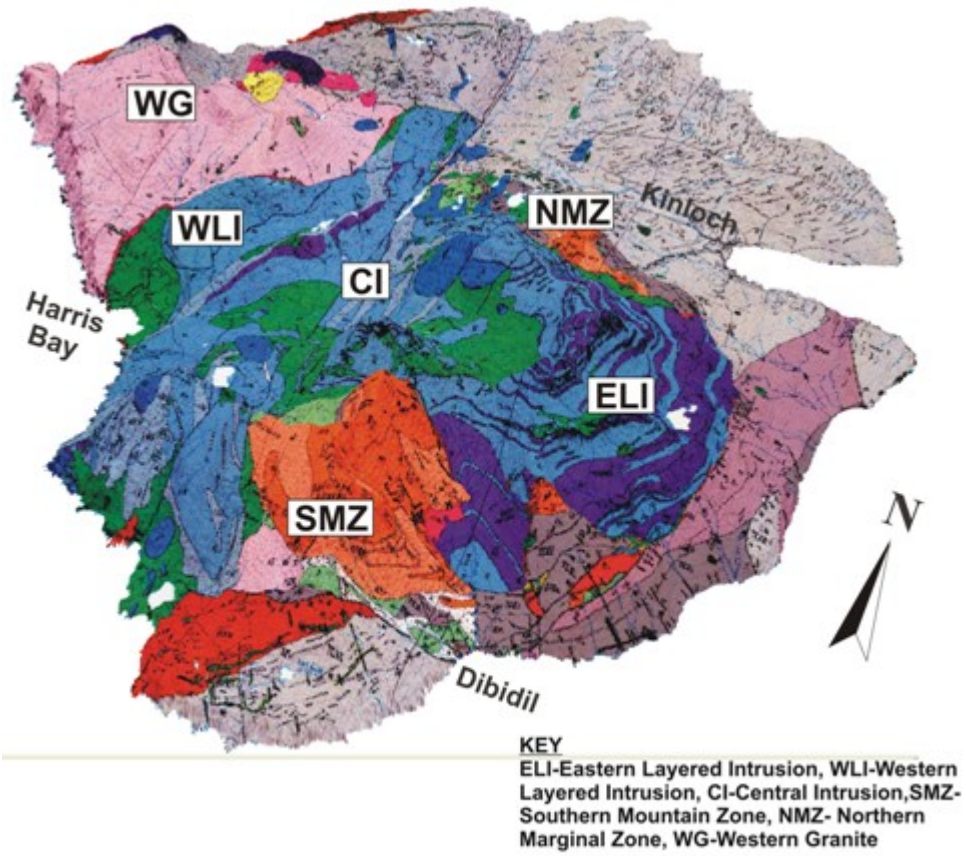
After the war came Lawrence Wager, Malcolm Brown, and John Wadsworth, the first to study the layered intrusions in detail. In work published in 1956, Brown mapped 15 separate units in the eastern part of the mafic layered centre. Each unit was shown to be cyclic, with a peridotitic base and a gabbroic to troctolitic upper part. He suggested that these formed by crystal settling processes in a magma chamber being regularly replenished by basaltic magmas - an important new concept that was soon applied to other intrusions round the world. Meanwhile, Wadsworth studied the layered rocks farther to the west, and identified spectacular peridotitic magma-chamber breccias. In 1960, these three published a classic paper on types of igneous cumulates, drawing much from their work on Rum.

Layered intrusions were not the only rocks being studied just then; George Black, from Edinburgh, examined the lavas exposed in western Rum, and showed that they rest unconformably on weathered granite - part of the Rum Central Complex. This was an important discovery, since it showed that these lavas are significantly younger than the adjacent intrusive rocks, and could not have come from the same volcano.



In the late 1950s Charles Hughes (Oxford) carried out the first detailed work on the silicic rocks of the Southern Mountain Zone. This complex area at the SE margin of the Rum Central Complex comprises breccias, tuffisites, and a range of felsic rocks that were all thought to be intrusive. Hughes suggested that the breccias were formed by the explosive effect of magma degassing (explosion breccias). He also identified igneous breccias and hybrid rocks, demonstrating that these had formed when felsic rocks were partially melted by later-intruding basic magmas. It became clear that the Rum Central Complex could be divided into two phases: an early phase of silicic, explosive magmatism, followed by a later phase of basic/ultrabasic intrusion.

In 1957, the Bullough family sold the island to the Nature Conservancy Council (now Scottish Natural Heritage). Rum became a National Nature Reserve, and access became much easier. An explosion of Rum research began, led by Ansel Dunham (Oxford), who examined the silicic rocks of the Northern Marginal Zone



Rum as a Nature Reserve

Through the 1970s and 80s, work on Rum's layered intrusions established them as classic examples. Work elsewhere had questioned crystal settling as a universal model for the formation of layered intrusions, drawing many workers to reconsider Rum. A paper by Fergus Gibb in 1976 modified the accepted model for the formation of the Rum layered intrusions, suggesting that the parent magma was ultrabasic rather than basaltic. Around the same time, Colin Donaldson was studying some of the unusual textures in the layered rocks, such as 'harrisites', with their long, skeletal olivine crystals, and he showed that these must have formed very rapidly and partly from intercumulus melt. In 1980, Herbert Huppert and Steve Sparks published a key paper in which they proposed that layering of the type seen on Rum could be produced when replenishing picritic liquids crystallise olivine on the floor of a magma chamber, until their density approaches that of the residual magma in the chamber, leading to mixing and the onset of gabbro rather than peridotite formation.

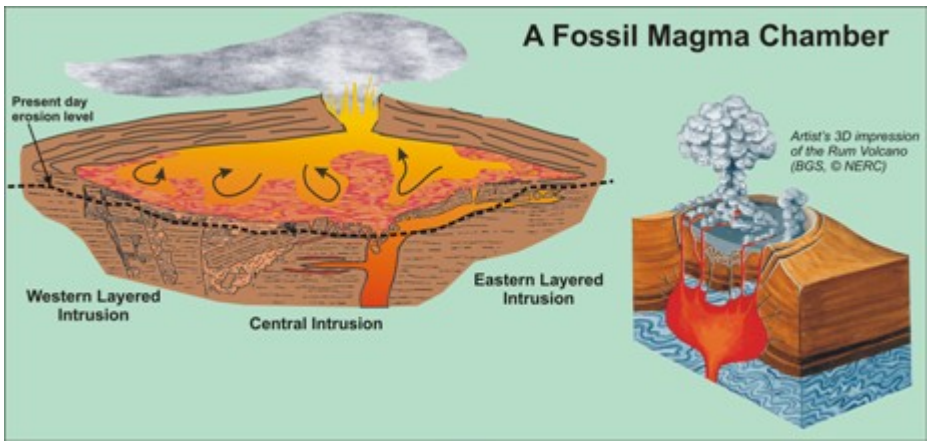
Around this time, a number of PhD students came to work on Rum, including Janet McClurg and Johannes Volker from Edinburgh, John Faithfull and Martin Forster from Durham, Stephen Tait and Jean Bedard from Cambridge, Iain Young from St. Andrews, Alan Butcher from Manchester, and Zenon Palacz from the Open University. Many of them aimed to study the Rum layered intrusions in the light of the new theories. Their detailed work allowed the different units within the Rum layered centre to be mapped out, and a number of intrusive

relationships to be recognised. Janet McClurg and Martin Forster recognised the presence of truly ultramafic rocks in the dyke suite on Rum, providing clues to the nature of the parent magmas for the layered intrusions. Much of this work was summarised in a special issue of the Geological Magazine, published in 1985. It is noticeable that many of those papers highlighted the importance of intercumulus fluid, and of post-cumulus processes, in the development of the textural and chemical features of the Rum layered intrusions.

During the later 1980s and the 90s, many workers including John Wadsworth, Brian Upton, Henry Emeleus, Jean Bédard and Johannes Volker challenged some accepted models for the Rum layered intrusions. In the Eastern Layered Intrusion, it was suggested that the peridotitic layers represented sills, intruded into troctolitic cumulates, and some features were ascribed to post-cumulus metasomatism. A model for the Central Intrusion involved magma rising along a broadly north-south feeder zone, with subsidence and faulting generating debris flows of material within the magma chamber (Figure 6).

In 1997, Rum research was summarised by Henry Emeleus in the comprehensive memoir for the British Geological Survey, Geology of Rum and the adjacent islands. This brought together detailed modern information about the geology of Rum; not only igneous geology, but also the sedimentary successions. More recent work by Mike Hamilton, Lynne Chambers and others has established the age of the Rum layered intrusions as 60.5Ma, with the lavas of western Rum being erupted approximately 0.5Ma later. Pebbles derived from Rum have been found in inter-lava conglomerates on Skye, and the lavas are in turn cut by the 59Ma Cuillin Centre. Thus, we know that magmatism on Rum was well and truly over before the layered intrusions on Skye began to form.

In the later 1990s, Henry Emeleus and Valentin Troll carried out new work the Northern Marginal Zone, and recognised evidence for two caldera cycles: the first involving doming followed by collapse and breccia formation, but with limited accompanying volcanism, while the second cycle was characterised by eruption of voluminous rhyodacitic ignimbrites. Interest in the layered intrusions of Rum has also recently been rekindled, through the application of detailed textural studies which followed on from Donaldson's early work, by the late Bob Hunter, Mike Cheadle and Marian Holness amongst others. For example Marian Holness and co-workers have been investigating the textural maturity of the layered intrusions using dihedral angles between crystals, and crystal size distributions have been used by Brian O'Driscoll and co-workers to quantify very rapid growth times for dendritic harrisitic olivines in the layered intrusions.



Rum research

Rum research has come a long way since MacCulloch's first visit, with work on the island and across the North Atlantic Igneous Province (NAIP) continuing apace, as illustrated by the presentations made at the Golden Rum meeting. Participants in the Golden Rum meeting were also treated to three days of wonderful weather, showing the rocks in the best possible light. The field excursions were ably led by Val Troll and Henry Emeleus, with insights from many others who have worked in the area, including Marian Holness, Brian Upton, Dougal Jerram, Mark Hallworth, Graeme Nicoll and Rachel Sides.

The Geological Society of London very generously supported student attendance at the conference, and with a new Rum field guide to be published in 2008, Rum will continue to be seen as a superb location for the study of magmatic processes for many years to come.

Further reading

- Bell, B R and Williamson, I T (2002). Tertiary Igneous Activity. In: Trewin, N H (2002). The Geology of Scotland (Fourth Edition). The Geological Society, London.
- Emeleus, C H and Bell, B R (2005). British Regional Geology: the Palaeogene Volcanic districts of Scotland (Fourth Edition). British Geological Survey, Nottingham.
- Emeleus, C H (1997). Geology of Rum and the adjacent islands. Memoir of the British Geological Survey, Sheet 60 (Scotland).
- Goodenough, K M and Bradwell, T (2004). Rum and the Small Isles: a Landscape Fashioned by Geology. Scottish Natural Heritage, Perth.
- Emeleus, C H and Troll, V. (in press): Excursion Guide to the Paleocene Igneous Rocks of the Isle of Rum, Inner Hebrides. (Edinburgh Geological Society: Edinburgh).

Geoscientist Feature March 2008 vol. 18: p.22-24

Acknowledgments

* KG publishes with the permission of the Executive Director of the British Geological Survey. DJ works at Durham University. The authors would like to acknowledge all those who have worked on Rum geology over the years.