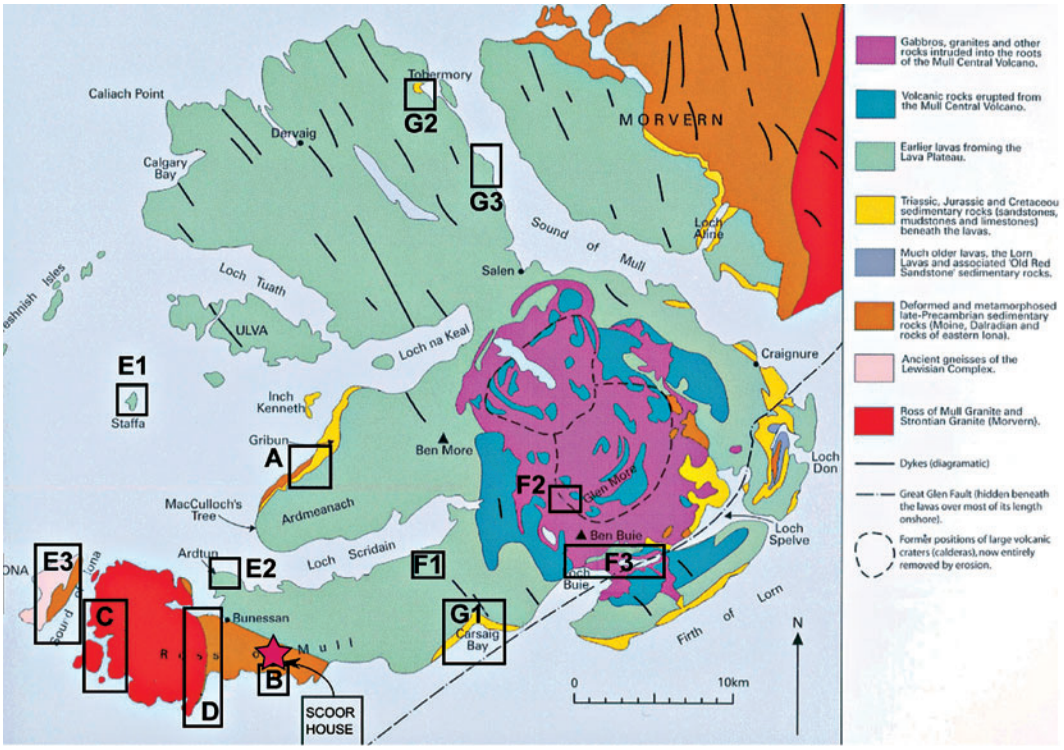

Figure 1. Simplified geological map of Mull. Figure: Tobias Fusswinkel

Kuva 1. Mullin yksinkertaistettu geologinen kartta. Kuva: Tobias Fusswinkel

The Isle of Mull field trip – Cross-cutting geological time

PAULA NIINIKOSKI AND TOBIAS FUSSWINKEL

This autumn (September 3rd–12th), we went on a ten day field trip to the Isle of Mull in Western Scotland. The trip was organized jointly between Dr. Tobias Fusswinkel from the University of Helsinki and Dr. Michael Marks from the University of Tübingen in Germany. The participants included 12 MSc and BSc students from Tübingen, and 11 PhD and MSc students from Helsinki. The start of the trip was a bit rocky, as getting the rental cars proved to be more difficult than expected. After the initial troubles the trip could head towards a different kind of rocky: Siccar Point with the famous unconformity described by James Hutton (see magazine cover). It was a lucky coincidence that there had not been any rain in several days, as the steep climb to the unconformity would have been dangerous, if

not impossible, had the ground been slippery. Even in good weather it was a bit of a challenge and prompted one of the students to point out: "This is why Hutton came by boat!"

Siccar Point is a wonderful place to visit for geology students, for one because important principles of geology are visible there in a large scale and also because it is one of the key places that shaped geology into a modern day science. It was there in 1788 that James Hutton found the most striking evidence for his theory of uniformitarianism and "Deep Time", or, as we would put it, for geological processes that work today in the same way and at the same pace as in the past, and that the Earth must therefore be very, very old. At the time this was a highly controversial concept as it challenged the commonly accepted view of the Earth having been created around tea time on October 23rd, 4004 BC, as calculated by James Ussher (1581–1656).

At Siccar Point, a steeply dipping succession of Silurian greywackes and mudstones is unconformably overlain by shallowly dipping Devonian red sandstones and conglomerates. The greywackes were deposited on the continental slopes of Laurentia during subduction of the Iapetus Ocean, marking the onset of the Caledonian orogeny. After the closure of the ocean the now tilted sedimentary succession was uplifted and exposed to the surface for 65 Ma, until they were covered by erosional detritus of the Caledonian Mountain chain brought in by fast flowing rivers during the Devonian. Of course, Hutton knew little of this, but his extensive studies of present day sedimentation and erosion rates immediately made him realize that a geological formation like the one at Siccar point could never have formed in a few thousand years.

After Siccar Point we started our journey towards Mull, an Inner Hebridean island on the western coast of Scotland, north of Islay and Jura. We spent the night in Oban, a town on the western coast, known as an important military base during World War II but nowadays mostly for tourism and its reputation as the Seafood Capital of Scotland. On Saturday morning we took the ferry to the Isle of Mull. What makes Mull a unique spot for a geological field trip is that a vast time span and variety of rock types, and different geological processes are visible in a relatively small area. One can time travel from the Archean through the Paleo- and Mesozoic into the Paleogene within a few hours' drive (Fig. 1). Many travelers coming to the UK from other parts of Europe worry about driving on the left side of the road. On Mull this is no challenge, as the roads are mostly single track, so everyone drives in the middle. There is very little traffic and most trouble comes from sheep and cows roaming in the wild, and not respecting any traffic laws (Fig. 2).

Figure 2. Giving way to cows. They were not in a hurry. Photo: Tobias Fusswinkel

Kuva 2. Retkeläiset antavat tilaa lehmille, jotka olivat sangen kiireettömiä. Kuva: Tobias Fusswinkel

Figure 3. Alternating sequence of Lower Jurassic shale and fossil rich limestone in Gribun. Photo: Paula Niinikoski

Kuva 3. Vuorottelevat varhaisjurakautiset saviliuskeet ja fossiilipitoiset kalkkikivikerrokset Gribunissa. Kuva: Paula Niinikoski

Figure 4. View of Scoor Bay, near our accommodation, with exposures of subvertical Late Proterozoic Moine group metasediments and Paleogene basalt sills. Photo: Paula Niinikoski

Kuva 4. Scoor Bay, lähellä majapaikkaamme. Lähes pystysuoria Moinen myöhäisproterotsooisia metasedimettejä leikkaavat paleogeeniset basaltit. Kuva: Paula Niinikoski

The first locality we took a close and detailed look at on Mull was Gribun, a series of beach outcrops of a condensed stratigraphic sequence where one can walk from Neoproterozoic basement rocks through the entire Mesozoic succession of sandstones, shales and limestones (Fig. 3), which is terminated by Paleogene lava flows. If one is lucky one can see a fish fossil. After the first day in the field we arrived at our accommodation, a charming cottage at Scoor Bay, surrounded by what seemed at first glance to be endless grassy hills and sheep as far as the eye could see. However, the next day we realized that only a short walk away, there was a sandy beach with exposures of steeply dipping and deformed Proterozoic metasedimentary rocks of the so called Moine group, crosscut by Paleogene basalt sills (Fig. 4), a beautiful location for our mapping exercise, which was executed in groups of three to four students, mixing the German and the Finnish students. Working together to figure out the mystery of the sills, or, as some might prefer to call them, horizontal dykes, worked well in getting to know each other.

On Monday and Tuesday we saw the Caledonian Ross of Mull granite intrusion (Fig. 5), its complex magmatic evolution, involving magma mixing and mingling with more primitive melts, its emplacement mechanism into the Proterozoic metasediments and the contact metamorphic aureole extending into the Moine rocks. There was a little bit of detective work involved again, as we were trying to find the different modifications of alumosilicates to establish the metamorphic history of the contact area.

The next day we travelled to two smaller islands west and north of Mull. First was the island of Iona, home to the oldest abbey in the UK, founded by St. Columba in the 6th century (Fig. 6). The famous book of Kells,

Figure 5. Students taking a close and detailed look at an aplitic vein within the Caledonian Ross of Mull Granite. Photo: Tobias Fusswinkel

Kuva 5. Opiskelijat katsovat läheltä ja tarkasti apliittista juonta Ross of Mull -graniitissa. Kuva: Tobias Fusswinkel

nowadays a tourist attraction in Dublin, was actually written here, but moved to Ireland for safekeeping during attacks by Vikings. Geologically Iona is made up of much older rocks than those on mainland Mull, comprising partly migmatized orthogneisses, amphibolites, pegmatites and anorthosites. After Iona we took a boat to Staffa, home to a magnificent columnar basalt (Fig. 7) belonging to the 2000-meter thick Paleogene lava flow succession which covers most of Mull. The weather was becoming windier, which made the one hour boat ride a little bumpy. Luckily, we were able to get on the shore, which is not always the case in bad weather (Fig. 8).

On Thursday we drove towards Tobermory, the largest town on the island and home to a whisky distillery of the same name. On the way we looked at sediments rich in plant fossils in between different Paleogene lava flows. The next day was spent in the Mull Central Volcanic Complex which intrudes the lava flows and is comprised of gabbros, picrites and granites. This concluded our stay on Mull

Figure 6. Iona Abbey, founded in year 563. Photo: Paula Niinikoski

Kuva 6. Vuonna 563 perustettu Iona Abbey. Kuva: Paula Niinikoski

and on Saturday morning we headed back to Edinburgh.

On Sunday morning it was time for our last excursion. It took place in the middle of Edinburgh, Holyrood Park. Professor Emeritus Brian Upton, from Edinburgh University, was kind enough to guide us through this famous Permo-Carboniferous volcanic complex with its numerous sills, vents and extrusive rocks. We also encountered our old friend James Hutton again, as Holyrood Park is the home of Hutton's Section (Fig. 9). Here a dolerite sill forming the famous Salisbury Cliffs tore away a slab of footwall sedimentary rock, tilting the broken ends of strata upwards as magma tried to force its way into a bedding

Figure 7. Spectacular columnar jointing and overlying chaotic entablature on Staffa. The lowermost unit is a fine grained volcanic ash. Photo: Tobias Fusswinkel

Kuva 7. Staffan basalttipylväät, alimpana hienorakeista vulkaanista tuhkaa. Kuva: Tobias Fusswinkel

Figure 8. Rough seas upon departure from Staffa putting waterproof clothing to the test. Photo: Yuan Shang

Kuva 8. Merenkäynti Staffalta lähtiessä oli testi vaatteiden vedenpitävyydelle. Kuva: Yuan Shang

plane, providing compelling field evidence for Hutton's theory of plutonism, which correctly assumed certain rock types to form from melts that can intrude earlier rocks. This was a point for Hutton's team in their debate with the Neptunists who assumed all rock types to have been precipitated from seawater. Brian's vast knowledge of the regional geology and his ability to paint a lively picture of the past brought the field trip to a great and memorable conclusion.

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Tiivistelmä

Isle of Mull -kenttäretki – Poikkileikkaus geologiseen aikaan

Helsingin ja Tübingenin yliopistojen yhteinen kenttäretki Skotlannin Isle of Mull -saarelle tehtiin 3.–12.9.2015. Ennen saarelle matkustamista vierailimme Siccar Pointissa, joka tuli kuuluisaksi James Huttonin löytäessä ja kuvatessa siellä sijaitsevan diskordanssin vuonna 1788. Siluurikautisten grauvakkojen ja savikivien päällä diskordantisti lepäävät devonikautiset hiekkakivet ja konglomeraatit (lehden kansikuva) tarjosivat kaivatun todisteen uniformitarianismista ja maapallon iästä, joka Huttonin mukaan oli paljon vanhempi kuin se noin 6000 vuotta, jonka James Ussher (1581–1656) oli laskenut.

Siccar Pointista matkustimme Isle of Mullille tutustumaan sen geologiseen historiaan (kuva 1). Tällä Sisä-Hebridien saarella on mahdollista muutamassa tunnissa tehdä aikamatka arkeeiselta kaudelta aina paleogeeniin saakka. Mull on rauhallinen saari, jolla liikennettä hallitsevat autojen sijaan lampaat ja lehmät (kuva 2). Ensimmäinen kohteemme täällä oli Gribun, jossa rannikon paljastumat vievät matkalle mesotsooisten hiekkakivien, saviliuskeiden ja fossiilipitoisten kalkkikivien halki (kuva 3). Seuraavana päivänä oli vuorossa kartoitusharjoitus aivan majapaikkamme lähellä Scoor Bayssä missä Moinen proterotsooisia metasedimenttejä halkovat paleogeeniset basaltit (kuva 4). Seuraavat kaksi päivää käytimme tutustumalla Ross of Mull -graniitti-intruusioon ja siihen liittyvään kontaktimetamorfoosiin (kuva 5). Tämän jälkeen olivat vuo-

rossa Ionan ja Staffan saaret. Ionalla sijaitsee Iso-Britannian vanhin luostari, Iona Abbey (kuva 6). Geologisesti Iona eroaa Mullin pääsaareen geologiasta iältään. Se koostuu huomattavasti vanhemmista migmatisoituneista ortogneisseistä, amfiboliiteista, pegmatiiteista ja anortosiiteista. Ionalta lähdimme Staffan saarelle katsomaan näyttäviä basalttipylväitä (kuva 7), jotka ovat osa Mullin pääsaarta peittäviä basalttisia laavavirtoja. Sää oli tuulinen, ja oli onnekasta että saatoimme nousta maihin Staffalla (kuva 8); aina huonolla säällä tämä ei ole mahdollista. Parin viimeisen päivän aikana vuorossa olivat Tobermoryn viskitislaamo ja Mull Central Volcanic Complex, jonka gabrot, pikriitit ja graniitit halkovat laavavirtoja.

Kenttäretkemme viimeinen päivä vietettiin Edinburghissa. Siellä meillä oli ilo ja kunnia saada emeritusprofessori Brian Upton Edinburghin yliopistosta oppaaksemme Holyrood Parkiin. Uptonin asiantunteva ja värikäs kerronta sai permi- ja hiilikauden aikaiset vulkaaniset muodostumat heräämään henkiin. Retkemme tavallaan päättyi siihen mistä se alkoikin: James Huttoniin. Holyrood Parkissa sijaitsee Hutton's Section (kuva 9): sedimenttikiviin tunkeutunut magma on repinyt paloja isäntäkivestä ja taivuttanut sedimenttikerroksia todistaen kiven magmaattisen alkuperän, Huttonin edustamien plutonistien mieliksi, mikä kumosi neptunistien edustaman käsityksen, että kaikki kivet muodostuvat vedestä saostumalla.

Figure 9. The group at Hutton's Section, with our guide Brian Upton (standing, second from the left). Photo: Tobias Fusswinkel

Kuva 9. Ryhmäkuva Hutton Sectionilla oppaamme Brian Uptonin kanssa (seisoo toisena vasemmalta). Kuva: Tobias Fusswinkel