Cover sheet:

A revised boundary between the Scoor Pelitic Gneiss and the Lagan Mòr Formation in SW Mull?

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Abstract

The Moine rocks of SW Mull have played a key role in our understanding of the Moine sequence in the NW Highlands. The Mull sequence was thought uniquely, to contain a continuous sedimentary sequence relating the Morar and Glenfinnan units seen elsewhere in Scotland. However, recent work by Krabbendam *et al.* (2021) and others, suggests that the Mull sequence does contain a major tectonic break, analogous to the Sgurr Beag Thrust of the mainland. This has implications for the existing stratigraphy used on Mull which have not previously been considered. The Lagan Mòr Formation, as currently shown on published geological maps, has little or no intrinsic integrity as a unit. It spans two sequences of unrelated rocks, separated by a major tectonic break. This work looks at this contact in detail, and suggests that the stratigraphic definitions of the Scoor Pelitic Gneiss and the Lagan Mòr Formation are modified so that the boundary between these units coincides with the tectonic break.

Introduction

Holdsworth *et al.* (1987) provided a detailed stratigraphy for the Moine metamorphic rocks in the Ross of Mull. Their key conclusion was that the Mull Moine sequence represented an original sedimentary sequence, with the lower (Morar-equivalent) Shiaba units passing upwards into the more pelitic Scoor and overlying Ardalanish units (Glenfinnan-equivalent). This is in contrast to the situation in most of the mainland Moine outcrop, where the Morar and Glenfinnan units are invariably separated by a major thrust (the Sgurr Beag slide/thrust). In this model, the Mull sequence thus provided the only primary record of the sedimentological relationship between these units.

Holdworth *et al.*(1987) defined the boundary between the Morar and Glenfinnan units at the top of their Lagan Mòr Formation, where flaggy, thinly bedded quartzites transitioned up into pelites with quartzite beds at the base of the Scoor pelite. More precisely, their “stratotype” defined the top of the Lagan Mòr Formation as being the top of the topmost quartzite unit (well exposed on the west side of the headland on the west side of Traigh Bhan na Sgurra) (Harris, 2010). This has the consequence of including some underlying pelitic beds within the upper part of the Lagan Mòr Formation, and emphasising their view of the transitional, sedimentary nature of the contact between the Lagan Mor, and the Scoor Pelite. This is the currently defined contact shown in the most recent version of the 1:50000k BGS map, and on the BGS Geology of Britain viewer.

However, recent work strongly suggests that the Morar-Glenfinnan boundary in Mull is also tectonic. Garnet ages in the Morar (Shiaba) units are much older than those in the Glenfinnan (Ardalanish) units (Bird, 2011), suggesting at least partly different metamorphic histories. Age distributions of detrital zircons in the Shiaba and Glenfinnan units are also different, with the Glenfinnan units containing zircons younger than some of the metamorphism of the Morar units, as on the mainland (Cawood *et al.*2015; Krabbendam, 2021).

Krabbendam *et al.* (2021) ascribe the intense flagginess of the Lagan Mòr Formation to deformation associated with the Sgurr Beag thrust/slide, and place the contact somewhere within the upper part of this unit. However, the the exact location of the slide in the rock sequence is not described in detail in their paper.

The pelites in the top few meters of the Lagan Mòr Formation, as defined by Holdsworth *et al*., are remarkably similar to those in the Scoor Pelite unit above. They share the same mineralogy, texture, and structure, with steep, crenulated gneissose/migmatitic fabrics, and locally, pegmatite segregations and veins (eg on inland exposures at An Crosan). This is exactly what would be expected if beds separated by a gradational sedimentary transition experience the same subsequent metamorphic history. However, this becomes problematic if the two units have different histories, and are only juxtaposed by late faulting.

It is notable that the pelites and quartzites at the very top of the Lagan Mòr Formation (under this definition) do not share the intense flaggy deformation/mylonization developed by the bulk of the unit lower down. This might suggest that the tectonic break does not correspond exactly to Holdworth et al's stratigraphic boundary, but instead occurs lower down **within** the unit as mapped by them. Accordingly, the Lagan Mòr Formation, as defined by Holdsworth *et al.* (1987) , has little or no intrinsic integrity in the new interpretation: it spans two sequences of unrelated rocks, separated by a major tectonic break.

Reinterpreting the pelites and thin quartzites within this uppermost part of the Holdsworth et al.'s Lagan Mòr Formation as part of the Scoor Pelite resolves these issues:

- the tectonic break then occurs at a contact marked by a change in deformational style and rock texture in the field. There is a strong linear trench/hollow eroded on the lower shore, which broadly coincides with this line (see Fig 1 below). In fact this break is where the original early C20th BGS workers mapped the contact bwtween gneissose pelite and quartzite (Fig 2) . This zone also contains lenses of epidosite, and late dolomite veins, which suggest some limited post-peak-metamorphic reactivation.
- the rocks above (the Scoor Pelitic Gneiss, and overlying Ardalanish Striped and Banded Formation) then have consistent lithological, stuctural and metamorphic features, and are likely to have been an originally contiguous sedimentary package. Although in general they are much less strained than the Lagan Mòrlithologies, there is definitiely an increase in strain over 2-5m towards the contact.
- the rocks below (the Lagan Mòr Formation and underlying Shiaba units) then have consistent lithological, structural and metamorphic features, and are likely to have been an originally contiguous sedimentary package.
- A large, but isolated muscovite pegmatite outcrop near An Crosan, currently mapped as hosted by the Upper Shiaba Psammite (despite a lack of outcrop around the pegmatite), would then fall within Scoor Pelitic Gneiss. This would fit much better with the abundance of similar pegmatites in the adjacent Scoor Pelitic Gneiss outcrops, and the total lack of pegmatite in nearby exposures of the extremely refractory and quartz-rich Upper Shiaba Psammite.

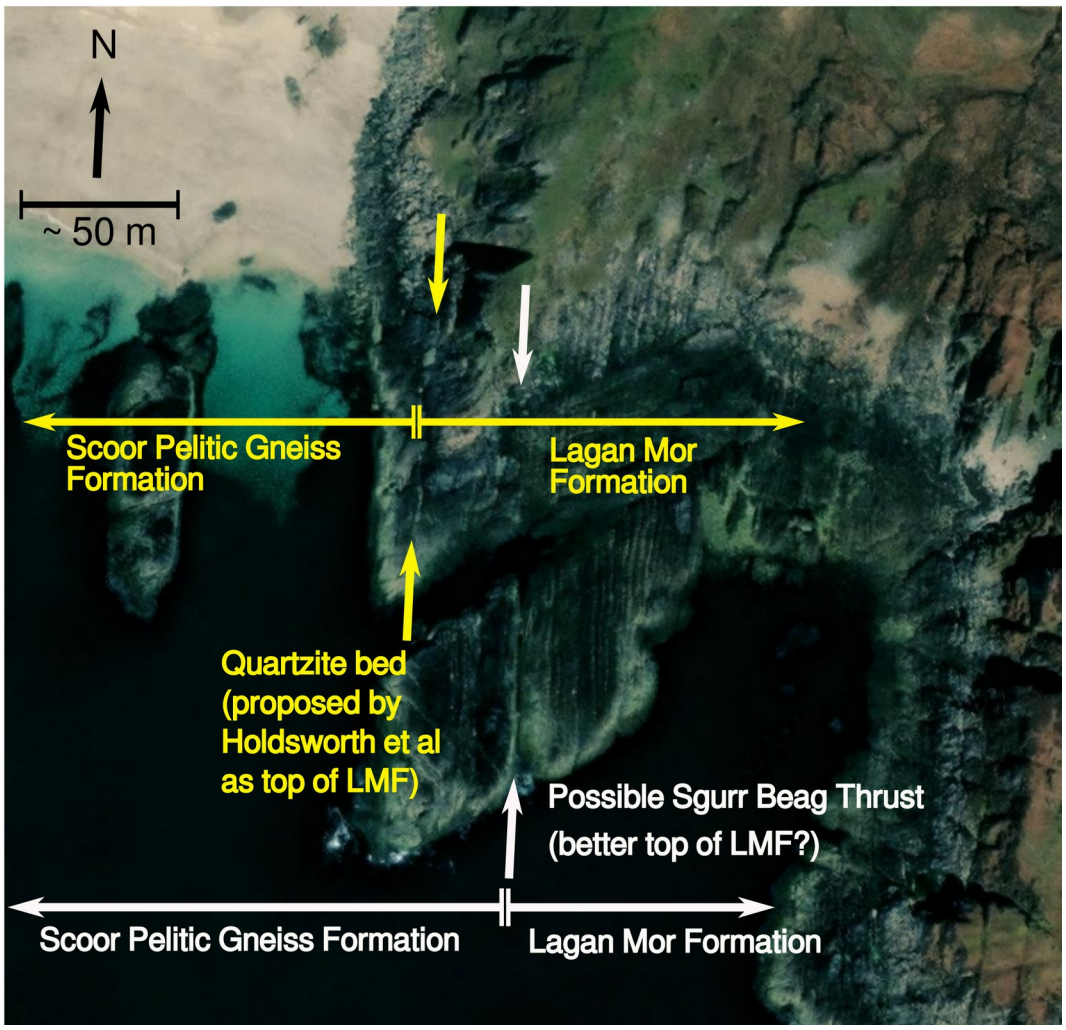

Fig 1 The headland at the west side of Traigh Bhan na Sgurra, showing the contact between the Lagan Mòr Formation and the overlying Scoor Pelitic Gneiss as defined by Holdsworth *et al.* (1987; shown in yellow), and the proposed new top of the Lagan Mòr Formation (in white). The image is centred approximately on UK grid reference NM4229 7185.

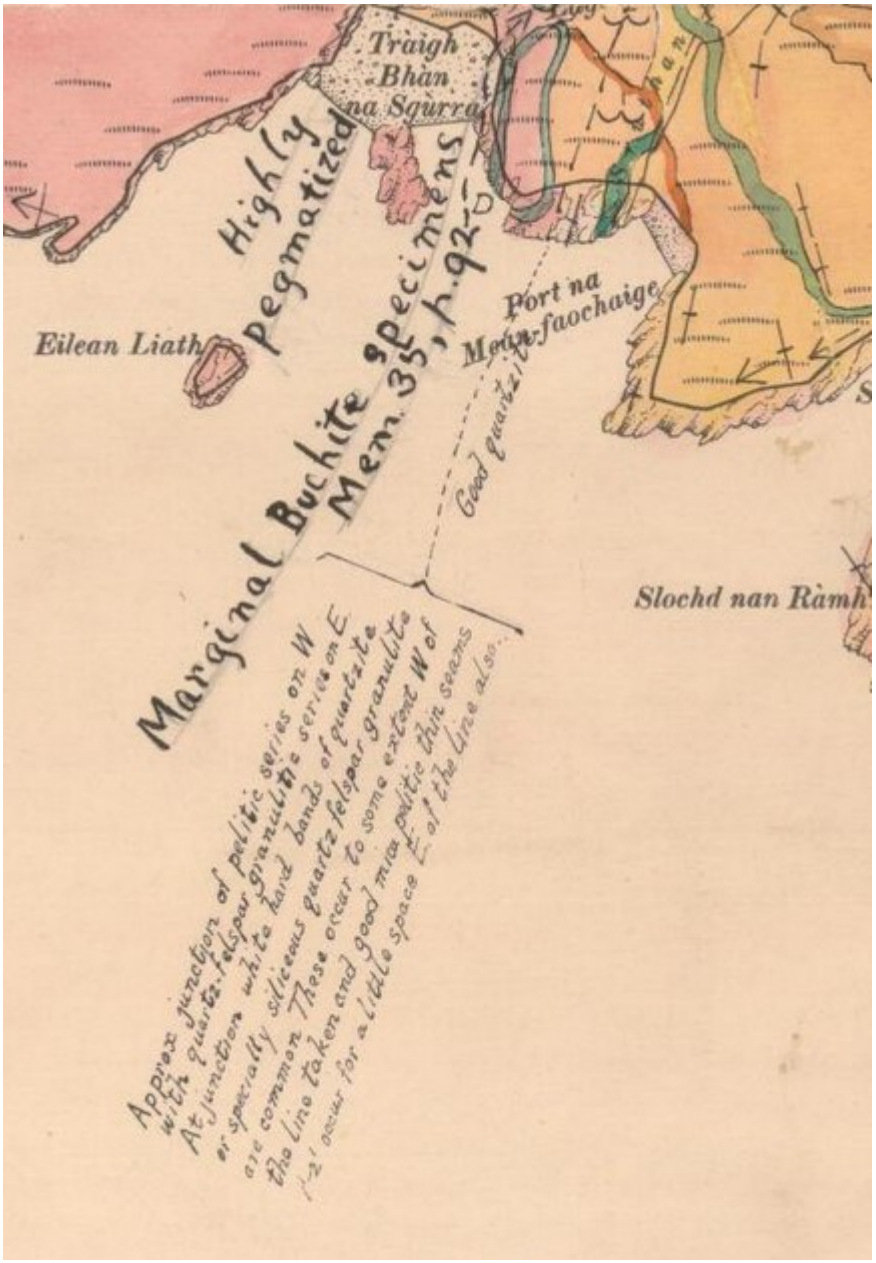

Fig 2 Detail from British Geological Survey (1920) 1:10 560 showing the position of the mapped boundary between the Scoor Pelitic Gneiss and the underlying quartzites, in the correct position. The note also accurately describes the occurrence of thin quartzites within the pelitic gneiss unit

Evidence for the age of the tectonic juxtaposition

Gneissose textures in the Scoor Pelitic Gneiss are sheared and deformed towards the contact. At least some of the metamorphism in the Scoor Pelitic Gneiss thus pre-dates at least some of the movement on the faulted contact. However, rare coarse pods of unfoliated muscovite-garnet rock in mylonitic quartzites at the very top of the Lagan Mòr Formation imply that at least some amphibolite-facies metamorphism post-dates at least some of the deformation. These pods are potentially dateable (*in situ* Rb-Sr by LA-ICPMS?), although thermal effects from the Paleocene sill just above might be an issue. Small later movements, (greenschist-facies or lower) with brittle fracturing and fluid flow in the fault zone are indicated by occasional epidote veins and pods, sub-parallel to the fault zone and foliation, and by the presence of small, sometimes vuggy, dolomite veins, often slightly cross-cutting (suggestion of a more NW-SE orientation?).

Final Questions: does the Lagan Mòr Formation exist?

In the model outlined above, the Lagan Mòr Formation has a tectonic, rather than primary sedimentological top. This raises a further question. What is the nature of its base? Does the Lagan Mòr Formation exist as a sedimentary lithostratigraphic package? Or is it simply a highly deformed zone where the Upper Shiaba Psammite has undergone very high strain? In the coastal exposures south of Lagan Mor, there are genuine lithological differences: thin, highly sheared biotite-rich beds are present here, and absent in the Upper Shiaba Psammite. These are visible in the coastal exposures, but further north, this zone is largely invisible, and marked by a gap in exposure between Scoor Pelitic Gneiss outcrops to the west, and low-strain Upper Shiaba Psmammite exposures further east. Despite the poor inland exposure, the Lagan Mòr Formation probably does represent a sedimentologically distinct package.

One other possibility (suggested by Fig 3 of Cawood *et al.*(2015)) is that perhaps the Sgurr Beag Thrust might be sited at the bottom of the "Lagan Mòr Formation", and the rocks classed as the "LMF" are simply a highly-strained basal facies of the Glenfinnan Group, with a higher proportion of quartzite beds than the more pelitic, gneissose rocks above. This model could be tested by looking for post-Renlandian detrital zircons within the LMF.

Conclusion

The Lagan Mòr Formation should be redefined, so that its upper boundary is defined by the tectonic break between the flaggy quartzites-with-finely-foliated-pelites, and the much lower-strained migmatized pelites-with-quartzites of the Scoor Pelitic Gneiss. BGS maps should be revised to display the top of the Lagan Mòr Formation at this position, a little east of the currently-displayed boundary.

References

British Geological Survey 1920 1:10 560 map sheet Argyllshire 120 https://largeimages.bgs.ac.uk/iip/mapsportal.html?id=13599312

Cawood, Peter A., Robin A. Strachan, Renaud E. Merle, Ian L. Millar, Staci L. Loewy, Ian W.D. Dalziel, Peter D. Kinny, Fred Jourdan, Alexander A. Nemchin, and James N. Connelly. 2015. 'Neoproterozoic to Early Paleozoic Extensional and Compressional History of East Laurentian Margin Sequences: The Moine Supergroup, Scottish Caledonides'. *GSA Bulletin* 127 (3–4): 349–71. https://doi.org/10.1130/B31068.1.

Harris AL 2010 "Ross of Mull"; in Strachan *et al.*(eds) An Excursion Guide to the Moine Geology of the Northern Highlands of Scotland National Museums of Scotland, 298 pp.

Holdsworth, R. E., A. L. Harris, and A. M. Roberts. 1987. 'The Stratigraphy, Structure and Regional Significance of the Moine Rocks of Mull, Argyllshire, W. Scotland'. *Geological Journal* 22 (2): 83–107. https://doi.org/10.1002/gj.3350220203.

Krabbendam, Maarten, Rob Strachan, and Tony Prave. 2021. 'A New Stratigraphic Framework for the Early Neoproterozoic Successions of Scotland'. *Journal of the Geological Society*, no. jgs2021-054 (October). https://doi.org/10.1144/jgs2021-054.