Depositional environments, Ordovician and Silurian, Southern Uplands

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Depositional environment

Typical sequence of turbidite beds. This example of Silurian (Llandovery) strata is exposed on the coast near Port Logan, Rhins of Galloway. P008471.
Flute casts, two examples from the Ordovician Kirkcolm Formation showing different styles and current directions: a) Finnarts Bay. P008425.
Regional geochemical images showing the distribution of (a) strontium (Sr) and (b) chromium (Cr). P912328.

The thin successions of oceanic, pelagic mudstone and chert that form the Crawford Group and Moffat Shale Group accumulated very slowly across the broad expanse of the Iapetus Ocean, laid down on the volcanic rocks of the oceanic crust. Vastly more extensive volumetrically are the thick sandstone successions deposited in submarine fan systems adjacent to the Laurentian continental margin, with turbidity currents as the principal depositional agents as described in Chapter 1. There are three dominant lithofacies: channel-fill sequences composed of massive sandstone, coarse grained, thickly bedded and locally associated with intraclast (sandstone) breccia and conglomerate; lobe or unconfined sheet-flow deposits composed of well-bedded, fine- to medium-grained sandstone with subordinate mudstone; and interchannel or interlobe deposits composed of siltstone and silty mudstone. These lithofacies are interbedded in vertical alternations that range from a few tens of metres to several hundred metres in thickness, but they also pass laterally from one to another on a scale of hundreds of metres to several kilometres. Most of the sandstones contain a high proportion of fine-grained matrix enclosing ill-sorted grains and so can be classified as wackes.

Individual beds may display a complete or partial array of the ideal turbidite features. If substantial turbidity flows closely follow each other, a thick sequence may build up in which graded sandstone beds become amalgamated, with only subtle variations in grain size determining the margins of each bed. In more distal parts of the fan, or as a result of small, low-density flows, thin and fine-grained sandstone beds may be pervasively laminated and separated by thicknesses of silty mudstone, the finest-grained part of the submarine fan succession deposited in areas that were spatially or temporally removed from most of the depositional activity. Where the base of a turbidite sandstone bed overlies the fine-grained top of its predecessor, it is usually sharp and clearly defined though groove and flute casts are common on many of the bed bases. If the bed is imagined as being rotated back to the horizontal, the orientations of the groove and flute
casts indicate the flow direction of the original turbidity current (the palaeocurrent), which also influenced the geometry of the ripples that show up in section as cross-lamination. This becomes an important interpretational tool when linked with the distinctive compositions of the sandstones forming some tracts, particularly those of the Leadhills Supergroup, which indicate derivation from a range of different provenance regions. Additionally, within the Leadhills Supergroup, the compositional differences are not only on a tract scale, but also appear within tracts as the interbedding of differently sourced sandstone units. This complexity has led to an extra level in the Ordovician stratigraphical hierarchy, relative to that applied to the Silurian rocks to the south, but that should not be taken to imply any fundamental change in tectonic and sedimentary processes at the Ordovician–Silurian boundary. However, to ensure clarity, the different levels of lithological variation do require slightly different structures to be adopted for the descriptive sections in the following account.

On a regional scale, compositional contrasts between the different tracts are sufficiently strong to be reflected in the geochemistry of the stream sediment eroded from their sandstones. Contoured maps of element concentration in stream sediment commonly show steep gradients coincident with or parallel to the tract boundary faults: two examples are shown in P912328. The dominant feature in the distribution of strontium (P912328a) is a marked decrease in its abundance across a narrow zone coincident with the Laurieston–Moffat Valley Fault. The change probably reflects variation in the plagioclase to K-feldspar ratio in the detrital grain population: more detrital plagioclase in the sandstones to the north-west of the fault, more detrital K-feldspar in the sandstones to the south-east. The distribution of chromium (P912328b) is dominated firstly by the effects of the mafic and ultramafic igneous rocks forming the Ballantrae Complex, and secondly by a broad zone of very high values running parallel to, but north-west of, the Laurieston–Moffat Valley Fault. Detrital chromite in the sandstones underlying this part of the Southern Uplands is the likely cause of this second anomalous zone. In detail, and from multi-element integrations, the regional, stream sediment geochemistry suggests an intensity of cryptic imbrication that has not been fully resolved by field studies. Another useful property that has been exploited in the differentiation of the Leadhills Supergroup tracts is the magnetic susceptibility of the different sandstones, which varies with the proportion of iron-rich minerals that they contain.

**Bibliography**


