6 River E

[NH 541 150]–[NH 554 136]

C.J. Banks

Published in: The Dalradian rocks of the northern Grampian Highlands of Scotland PGA 124 (1–2) 2013
https://doi.org/10.1016/j.pgeola.2012.07.010 Also on: NORA

6.1 Introduction

The River E, which flows from the Monadhliath Mountains into the south end of Loch Mhor, some 4 km south-east of Foyers, contains excellent exposures of Grampian Group strata. The river section provides a transect across the Glen Buck Pebbly Psammite Formation of the Glenshirra Subgroup, exposed as a structural inlier in the core of an upright F2 anticline (Figure 5.15). Clean-washed exposures of feldspathic pebbly psammites, psammites and less abundant pelites, exhibit abundant well-preserved sedimentary structures, a rarity in this part of the Northern Grampian Highlands due to ubiquitous metamorphism and deformation (see also the *Rubha na Magach* and *Garva Bridge* GCR site reports). Slumped horizons, load casts, rip-up clasts, trough and tabular cross-lamination, planar lamination, grading and dewatering structures are all preserved due to low strain in the hinge-zone of the major fold (Figure 5.16). Indeed, the detail exhibited allows palaeoenvironmental interpretations to be made with a resolution comparable to that in undeformed Phanerozoic successions.

The base of the Glen Buck Pebbly Psammite Formation is nowhere exposed and hence its relationship with postulated basement rocks of the Badenoch Group is unknown. The upper contact, with schistose semipelite and micaceous psammite of the Corrieyairack Subgroup, defines the inlier but it is not exposed in the river section described here (see the BGS 1:50 000 Sheet 73E (Foyers, 1996). Where seen, the contact is sharp, but it is strongly deformed by a ductile shear-zone that exploited competency contrasts between lithologies of the Corrieyairack and Glenshirra subgroups.

On the BGS 1:50 000 Sheet 73E (Foyers, 1996) the rocks of the inlier were included within the Gairbeinn Pebbly Psammite Formation, now reassigned to member status within the Garva Bridge Psammite Formation (see the *Lochain Uaine* and *Garva Bridge* GCR site reports). However, a recent re-interpretation of the relationships indicates a correlation with the Glen Buck Pebbly Psammite Formation to the south-west (Banks and Winchester, 2004; Banks, 2005).

6.2 Description

An estate track provides easy access and the best sections occur in the River E, east and north of the ruins at [NH 5556 1370]. The most common lithology within the Glen Buck Pebbly Psammite Formation is a medium-grained feldspathic psammite that occupies *c.* 75% of the river section. Scattered angular clasts of quartz and/or K-feldspar form less than 5% of the rock. This lithology varies in colour from salmon pink (reflecting oxidation of iron minerals), through cream (quartzose lithologies) to dark grey (more micaceous lithologies).

These beds of feldspathic psammite have a lens, sheet or wedge morphology up to 50 cm in thickness (Figure 5.16)a. They display excellent tabular and trough lamination with multiple re-activation surfaces. Cross-laminated beds commonly have a pebbly lag or heavy mineral concentration at their base (Figure 5.16)b. Sets usually attain *c.* 0.1–0.15 m in thickness with co-sets *c.* 0.2–0.3 m thick. Ripple cross-lamination is very common and occurs at the top of cross-laminated beds of psammite or pebbly psammite. Psammite beds at [NH 546 136] preserve low-angle (<10°) cross-sets with migration directions opposite to the surrounding background tabular cross-laminae. Some rare beds thin and display a reduction in clast abundance and size in a direction opposite to foreset migration.

Common erosional scour-and-fill structures are developed at the base of the feldspathic psammite units and have a deep (*c.* 0.05 m) and narrow (*c.* 0.1 m) morphology with intraclasts scattered throughout the scour fill. Well-developed examples occur at [NH 5445 1410]. A variety of load casts, flame structures, sand volcanoes and injection structures are well developed; good exposures of injection structures can be viewed at [NH 5445 1410] (Figure 5.16)c.

Pebbly psammite occupies approximately 25% of the section, and is commonly matrix supported, with granule- to pebble-sized clasts of single mineral grains (K-feldspar or quartz) or of quartzofeldspathic aggregates, which are rarely pegmatitic. The clasts are always angular, which might reflect either original immature depositional texture or the synmetamorphic overgrowth of detrital grains. The pebbly psammites can be divided into two groups–beds that are internally massive (disorganized) and beds that show well-developed sedimentary structures (organized).

Massive beds of pebbly psammite tend to form sharp, parallel-sided sheets between 0.1 and 1.0 m thick, with erosive bases. Bed tops may show cross-stratification, indicating later reworking. Some thicker units show inverse grading from granule- to pebble-sized clasts [NH 5463 1363]. These massive sheets are stacked and interbedded with organized beds of pebbly psammite (Figure 5.17).

Organized pebbly psammite beds are discontinuous laterally and have lensoid morphologies. They can have gradational lower contacts with more-massive pebbly sheets (Figure 5.17). Intricate tabular and trough cross-stratification is well preserved. Cross-strata form co-sets *c.* 0.1–0.3 m thick with sets ranging from 0.05–0.1 m thick [NH 5463 1363].

Semipelite forms a very minor constituent of the River E succession. Where developed, it is rarely extensive, either laterally or vertically. It most commonly occurs as micaceous drapes on psammitic cross-laminae or as thicker lenses between psammitic macroforms. No internal sedimentary fabric or texture is preserved in this lithology as a consequence of coarse-grained recrystallization during regional metamorphism.

Slumped bedding forms a relatively minor, but locally important, component of the stratigraphical succession described here. Beautifully preserved, contorted and folded slumped layers up to 2 m thick occur at [NH 5460 1367]. These slump folds occur within layers that are demonstrably stratabound by planar beds; the slump structures have no systematic axial trend and are disharmonic to the regional fabric.

6.3 Interpretation

The metasedimentary rocks exposed within the River E inlier, are interpreted as having been deposited within alluvial and fluvial environments. The assemblages of sedimentary structures indicate that two depositional processes were dominant: sediment gravity flows (debris flows and slumps) and traction currents.

Disorganized and massive, matrix-supported pebbly psammite sheets indicate deposition by cohesive debris flows (Miall, 1992). Rare inverse grading suggests that significant dispersive pressures (probably from grain collision) operated within these flows (the density-modified-grain flow of Lowe, 1976). Flows eroded the underlying substrate but were gradational with, and reworked by, stream flows as is suggested by the development of cross-lamination in pebbly sheet tops.

Sediment gravity flows are also represented by slumped units. These indicate failure and collapse of a topographical high (a bank or cliff) perhaps by fluvial undercutting. The intensity and ductile nature of the slumped folding suggest that these sediments were unlithified and water saturated when this occurred.

Well-developed tabular and trough cross-lamination within organized pebbly psammite and psammite indicate deposition by traction currents. Considering the palaeo-grain size of the sediment, these traction currents would have been almost certainly subaqueous; no indication of aeolian processes has been found. The dominance of tabular cross-stratification indicates the common accretion of straight-crested ripples and dunes. The rarer occurence of trough cross-bedding is the result of higher velocity flows creating more-linguoid ripples and lunate dunes (Allen, 1963). Weaker, dilute traction currents are indicated by developments of ripple lamination within non-pebbly units. The unidirectional nature of the tabular cross-sets indicates a consistent migration direction of these fluvial sand bodies, which could be either downstream or lateral. Rare low-angle cross-sets with palaeocurrents opposite to the general trend indicate the development of antidunes, where standing waves promote upstream migration of bedforms.

Common scour-and-fill structures suggest very high current velocities eroding the substrate. Deep, narrow scours and intraclast-rich scour-fills suggest coarse bedload abrasion rather than fluid erosion of the substrate (Collinson and Thompson, 1988). Rapid deposition onto a water-saturated substrate is recorded by common dewatering structures.

The pebbly and feldspathic psammites exposed in the River E therefore represent a variety of lateral and downstream accretion architectural elements (sensu Miall, 1985). However, due to poor lateral continuity of exposure away from the river section, three-dimensional control on the geometry of these sand bodies is difficult to establish.

The pebbly deposits are interpreted as longitudinal gravel bars, point bars, thoroughly reworked debris flows or sheet-flood deposits. The non-pebbly deposits represent a spectrum of sand bars, sand waves, dunes and ripples. Some of these non-pebbly psammite beds represent point bars as is suggested by lateral grain-size reduction in the opposite direction to palaeocurrents. Palaeocurrents reflect lateral migration of bars, whilst lateral grain-size reduction indicates flows becoming weaker up the bar (Miall, 1992).

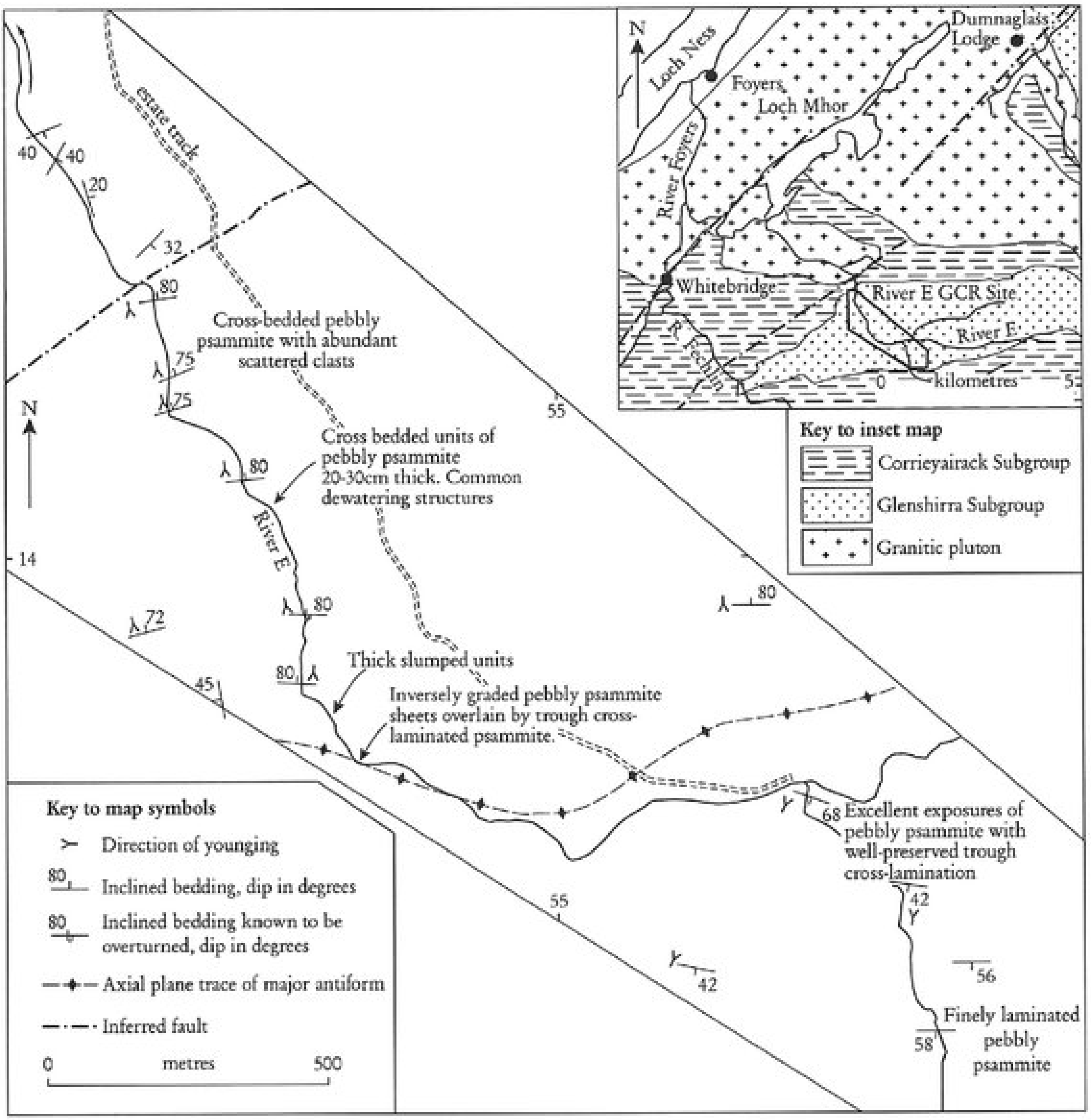
The quartz-K-feldspar-dominated clast population indicates that both the debris flows and the river systems were fed from a quartzofeldspathic gneissose or granitic hinterland.

6.4 Conclusions

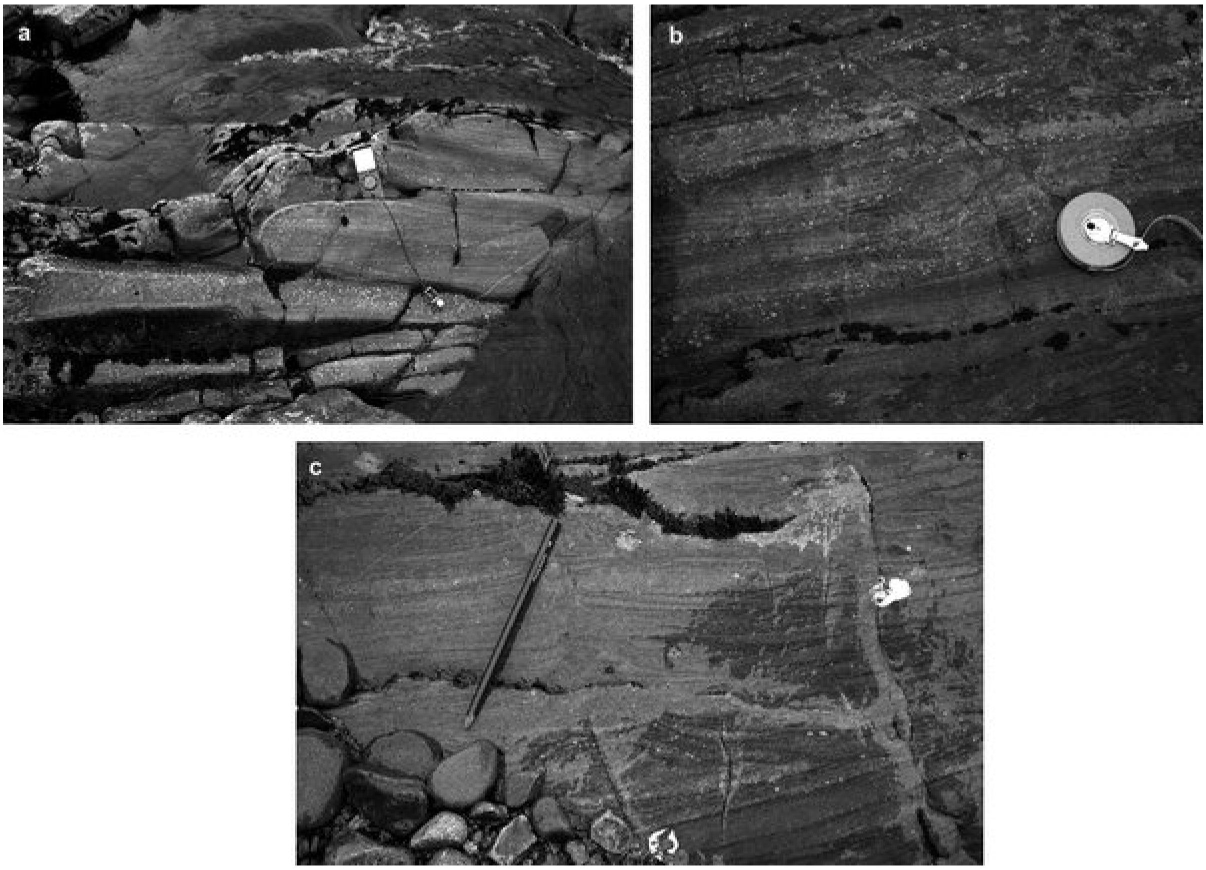
This near-continuous section in the River E exhibits some of the most spectacular Neoproterozoic sedimentary structures in Britain. Here, feldspathic pebbly psammites crop out in the core of an upright F2 antiform, where the amount of strain is far less than is usual in the Northern Grampian Highlands, preserving excellent examples of sedimentary slumping, load casts, rip-up clasts, trough and tabular cross-lamination, planar lamination, grading and dewatering structures.

The strata are representative of the Glenshirra Subgroup, the lowest division of the Grampian Group and the detailed evidence at this site indicates that the original sediments were deposited within continental alluvial and fluvial environments. Traction deposition of a mixed sandy and gravely bedload took place in braided river systems. This palaeoenvironment was subject to influx of debris flows that introduced coarse clastic sediment sourced from a nearby quartzofeldspathic gneissose or granitic terrane.

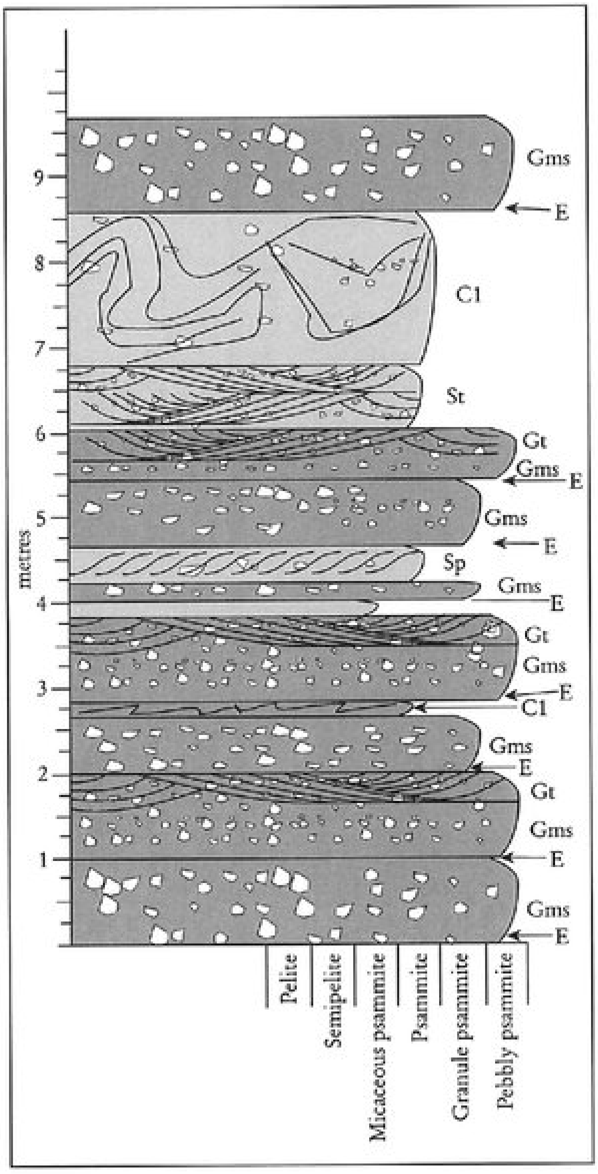
References



(Figure 5.15) Map of the River E section.



(Figure 5.16) (a) Inversely graded, matrix-supported pebbly psammite overlain by a psammite displaying a variety of cross-lamination and some dewatering structures. Beds young upwards in the photo. River E [NH 5463 1363]. Open compass is 17.5 cm long. (b) Pebbly lag at the base of trough cross-laminated psammite. Beds young upwards in the photo. River E [NH 5458 1375]. Tape measure is 10 cm in diameter. (c) Well-preserved sand volcano in heterolithic pink and grey psammite showing ripple lamination. Beds young upwards in the photo. River E [NH 5445 1410]. Pencil is 14 cm long. (Photos: C.J. Banks.)



(Figure 5.17) Sedimentary log for the section in the River E at [NH 5460 1367], illustrating facies stacking pattern in pebbly psammite-dominated parts of the succession. Gms matrix-supported pebbly psammite (debris flow), Gt trough cross-laminated pebbly psammite (stream-flow reworking or longitudinal bars), Sp planar laminated psammite (sandy bar form), St trough cross-laminated psammite (sandy bar form), Cl slumped layer, E erosive base.