NEW GEOCHEMICAL ANALYSES OF NINE RHYOLITIC AXES OF GROUP VIII TYPE, AND COMPARISON WITH AXE MANUFACTURING SITES IN SOUTH-WEST WALES

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ABSTRACT

Nine Neolithic polished axe-heads of rhyolitic rock (Implement Petrology Committee classification "Group VIII") were characterised non-destructively using portable X-ray fluorescence analysis in order to investigate the extent of variation in the composition of Group VIII axes, and to compare them with rhyolitic debris from two axe manufacturing sites in south-west Wales reported by David and Williams in 1995 (Glyn-y-Fran and Glandy Cross). Two additional Group VIII axes for which analyses have been published previously are also discussed here. Six axe-heads out of a total of eleven have compositions consistent with an origin at the axe factories; a further axe may be from Glandy Cross. The other four axes do not match the debris at the factory sites. Axes of Glyn-y-Fran and Glandy Cross compositions reached dispersed sites in central, southern, and eastern England, suggesting some human transport or trade.

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Keywords: Neolithic, Wales, Glyn-y-Fran, Glandy Cross, axe-head, rhyolite, Group VIII, petrology, geochemistry, portable XRF, artefact distribution.

INTRODUCTION AND BACKGROUND

Implement Petrology Committee (IPC) Group VIII comprises over one hundred Neolithic polished stone axe-heads of fine-grained rhyolitic rock (Clough & Cummins 1988). The axe group was first defined seventy years ago (Keiller *et al*. 1941) and the rhyolitic material was described as consisting of "an even and finely-textured micro-crystalline mosaic of quartz and possible feldspar with scattered, irregular non-homogeneous accumulations of leucoxene" (*op. cit*. 63). This and subsequent reports also use the terms "a silicified rhyolitic glass, fine tuff or sediment" (Stone & Wallis 1947, 51 & 1951, 122). More recent, analytical, work has suggested that Group VIII implements are a geochemically varied assemblage (Williams-Thorpe *et al*. 1999; Jones & Williams-Thorpe 2001).

Several geological source locations, mainly in south-west Wales, have been proposed for Group VIII (largely from IPC studies, summarised in Williams-Thorpe *et al*. 1999, 231; David & Williams 1995). Of these potential sources, the most important are two axe manufacturing sites close together in eastern Preseli: Glyn-y-Fran and Glandy Cross, reported by David and Williams (*op.cit.*). Here, glacially deposited boulders and cobbles of rhyolitic rock were used for axe manufacture, and petrographic features of worked debris have been likened to Group VIII (Jenkins in David & Williams *op. cit*., 459).

Geochemical comparison of Group VIII assigned axes with Glyn-y-Fran and Glandy Cross material has been done only for two axes (Williams-Thorpe *et al*. *op. cit*.; Jones & Williams-Thorpe *op. cit*.). In the present paper, new geochemical analyses for nine Group VIII axe-heads are presented and compared with analyses of material from Glyn-y-Fran and Glandy Cross. The two Group VIII axes previously studied by Williams-Thorpe and colleagues are also included in this comparison.

THE STUDIED AXES, GEOCHEMICAL CHARACTERISATION AND COMPARISON WITH GLYN-Y-FRAN AND GLANDY CROSS

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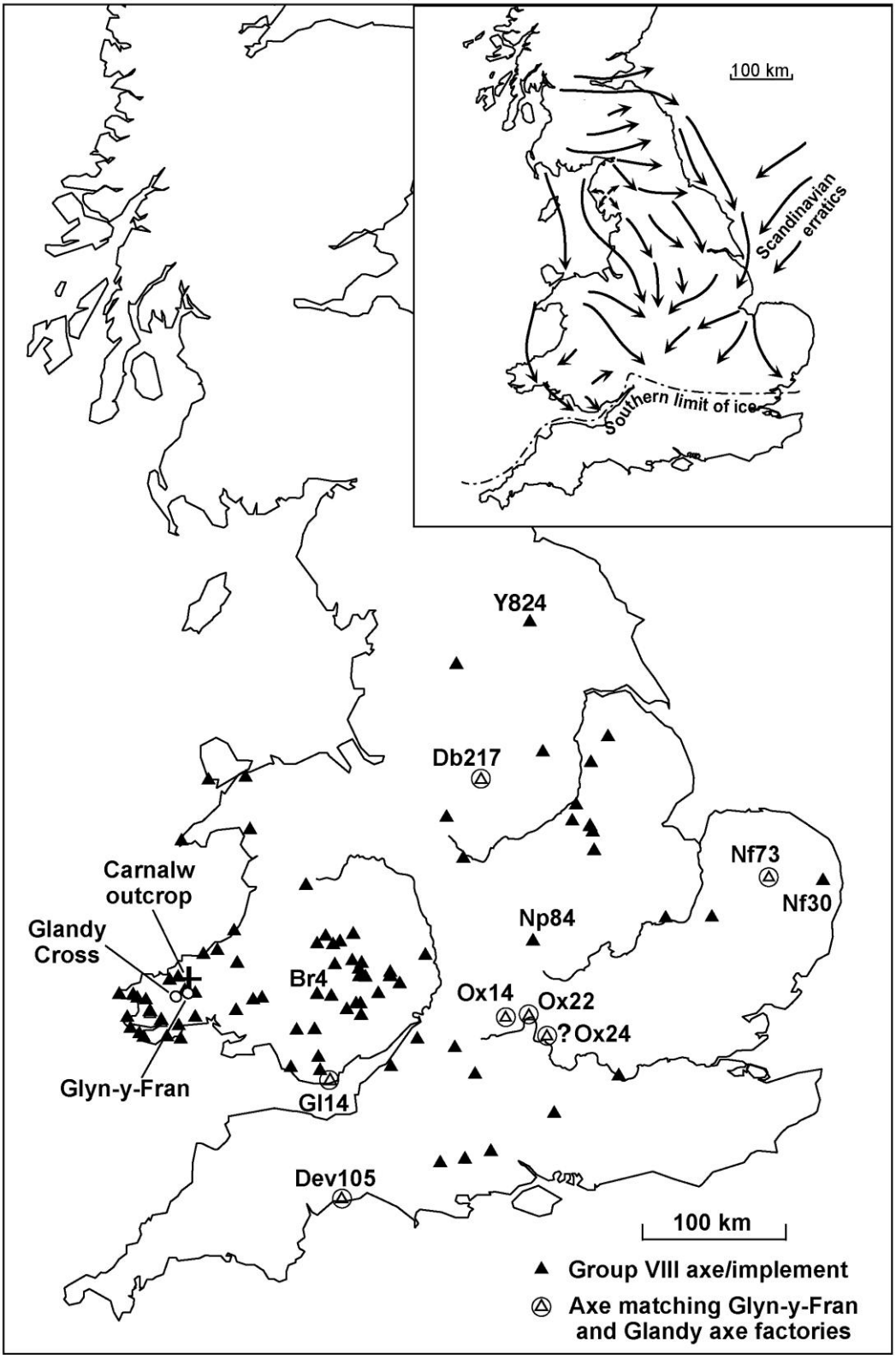

Figure 1. Map of part of the UK showing the find locations of the studied axes (labelled triangles) within the wider distribution of Group VIII implements (from Clough & Cummins 1988, 272) and highlighting those axes assigned below to manufacturing sites in south-west Wales. Places discussed in the text are named. The inset shows glacial ice directions within Anglian limits, for discussion later in the paper (glacial information taken from Williams-Thorpe et al. *2003 Figure 7 which is redrawn and simplified after Charlesworth (1957) and Bowen (1991).*

IPC ref.	*Other ref.*	*Museum*	*Find location*	*Comment on context and associations; literature refs.*	*Description of axe material*
Db217	BM Lucas 448	London BM	Minninglow, Derbyshire	Found "near Minninglow" June 1872	Fine-grained pale grey-blue with thin (<1 mm) weathered layer of creamy brown-grey, some dark brown patches
Ox14	1896.Pr.56	Oxford Ashmolean	Eynsham, Oxfordshire	Noted as "basalt" in Salzman (1939, 241; illustrated opposite 239)	Fine-grained, black, scattered ?feldspar crystals to 1 mm
Ox22	1950.386	Oxford Ashmolean	Cassington, Oxfordshire	From a small pit in gravel and near a ditch with (secondary) finds of Neolithic - Bronze Age date (Kirk & Case 1950, 104)	Fine-grained blue with scattered ?feldspar crystals 0.5–1 mm; paler grey-blue weathered surface (<1 mm)
Nf73	NCM L.1868.3	Norwich Castle Museum	Deopham, Norfolk	Find place noted with a question mark in IPC lists (Clough & Cummins 1988, 178)	Blue grey with dark streaks
Dev105	BM 1953.12-4.1	London BM	Branscombe, Devon	Found near Branscombe church	Pale browny cream weathered surface with some darker mottling (probably fresher rock showing through)
Gl14	36-202.33	Cardiff NMW	Barry, Glamorgan	From near Peiro's Abbey; Grimes 1951 catalogue no.101; previously published (Williams-Thorpe *et al.* 1999)	Fine-grained bluish, scattered ?feldspar crystals, fabric visible; thin weathered layer of grey-white colour
Ox24*	1976.185	Oxford Ashmolean	Culham, Oxfordshire	Found with a quantity of Neolithic flintwork in a ploughed field	Very fine-grained, blue, weathered (<1 mm) paler (creamy whitish) surface
Br4	42.24	Cardiff NMW	Llangasty-Talyllyn, Brecon	From Trebinshun Farm (Grimes 1951, catalogue no. 118); previously published (Williams-Thorpe *et al.* 1999).	Very fine-grained aphyric black, grey-black weathered layer <1 mm
Nf30	NCM 3.945	Norwich Castle Museum	Thurlton, Norfolk		Grey-blue fine grained matrix with brownish crystals <1 mm; one side has aligned holes (perhaps weathered out crystals) <2 mm
Np84*	D 236.1978	Northampton Guildhall Museum	Towcester, Northants		Very fine-grained, flinty texture, pale grey banded fabric; bands are darker grey-blue; whitish ?clasts, aligned
Y824	BM (66)	London BM	Raskelf, Yorkshire		Very fine-grained, blue, flinty texture; very thin weathered layer (<1 mm) of grey-brown colour

Table 1 Details and descriptions of the studied axes. All artefacts are unperforated polished axe-heads (Ox24, Gl14 and Np84 very incomplete). Axe definitions as "Group VIII" are following IPC lists (Clough & Cummins 1988); Ox24 and Np84 (*) are listed as "Near VIII". BM: British Museum, NMW: National Museum of Wales. Old county names for Wales quoted from IPC lists.

Ref. No.	***Site name***	***K_2O***	***CaO***	***TiO_2***	***MnO***	***Fe_2O_3***	***Ba***	***Nb***	***Pb***	***Rb***	***Sr***	***Y***	***Zr***
Axes		***wt %***	***wt %***	***wt %***	***wt %***	***wt %***	***ppm***	***ppm***	***ppm***	***ppm***	***ppm***	***ppm***	***ppm***
Db217	Minninglow	0.31	0.46	0.11	0.05	2.84	96	9	41	< 5	43	42	247
Ox14	Eynsham	0.29	0.93	0.21	0.04	1.05	155	14	143	8	52	56	252
Ox22	Cassington	0.21	0.66	0.11	0.06	0.90	61	16	22	5	47	61	252
Nf73	Deopham	0.23	0.60	0.16	< 0.04	0.92	40	16	24	< 5	31	62	279
Dev105	Branscombe	0.33	0.74	0.15	< 0.04	2.03	43	14	80	< 5	40	52	285
Gl14	Barry	0.18	0.56	0.11		0.77	65	8	186	< 5	51	47	259
Ox24	Culham	0.23	2.01	0.66	< 0.04	2.78	85	23	29	14	158	31	185
Br4	Llangasty	3.11	0.46	0.06		1.38	4395	13	61	31	138	62	492
Nf30	Thurlton	3.82	0.57	0.16	< 0.04	0.40	838	29	79	26	53	100	456
Np84	Towcester	3.17	0.53	0.19	< 0.04	0.20	800	23	25	30	47	106	446
Y824	Raskelf	1.04	1.41	0.16	0.04	2.19	363	5	39	23	75	34	121
Axe factory material													
226/F4H5	Glyn-y-Fran			0.17		1.73	26	15	8	<2	25	82	270
CRY1	Glyn-y-Fran			0.20			21	17	16	<2	40	100	291
190/N11	Glandy Cross			0.18		2.77	36	12	8	<2	41	88	313
192/M10	Glandy Cross			0.89		3.59	55	16	<5	<2	165	32	150

Table 2 Geochemical analyses of axes and axe factory material. Axe analyses: by portable X-ray fluorescence, n=2 per axe (3 for Y824), analytical performance in Potts et al. *1995. Repeatability within analyses of individual axes varies by element (reflecting, in part, sensitivity of that element in PXRF) and is: 6 % for K, 7% for Zr, Y and Sr, 10 % for Ti, 11 % for Ba, 13 % for Nb and Ca, 14 % for Fe, 21 % for Pb, 33 % for Mn, and 40 % for Rb (averages of 1 relative standard deviation (rsd) of mean for each axe). Barry and Llangasty axes previously reported by Williams-Thorpe* et al. *1999 and Jones & Williams-Thorpe 2001. Axe factory analyses: laboratory XRF, from David and Williams 1995; discussion of analytical performance in Potts 1987 and Potts* et al. *1984. Missing data not given in data source.*

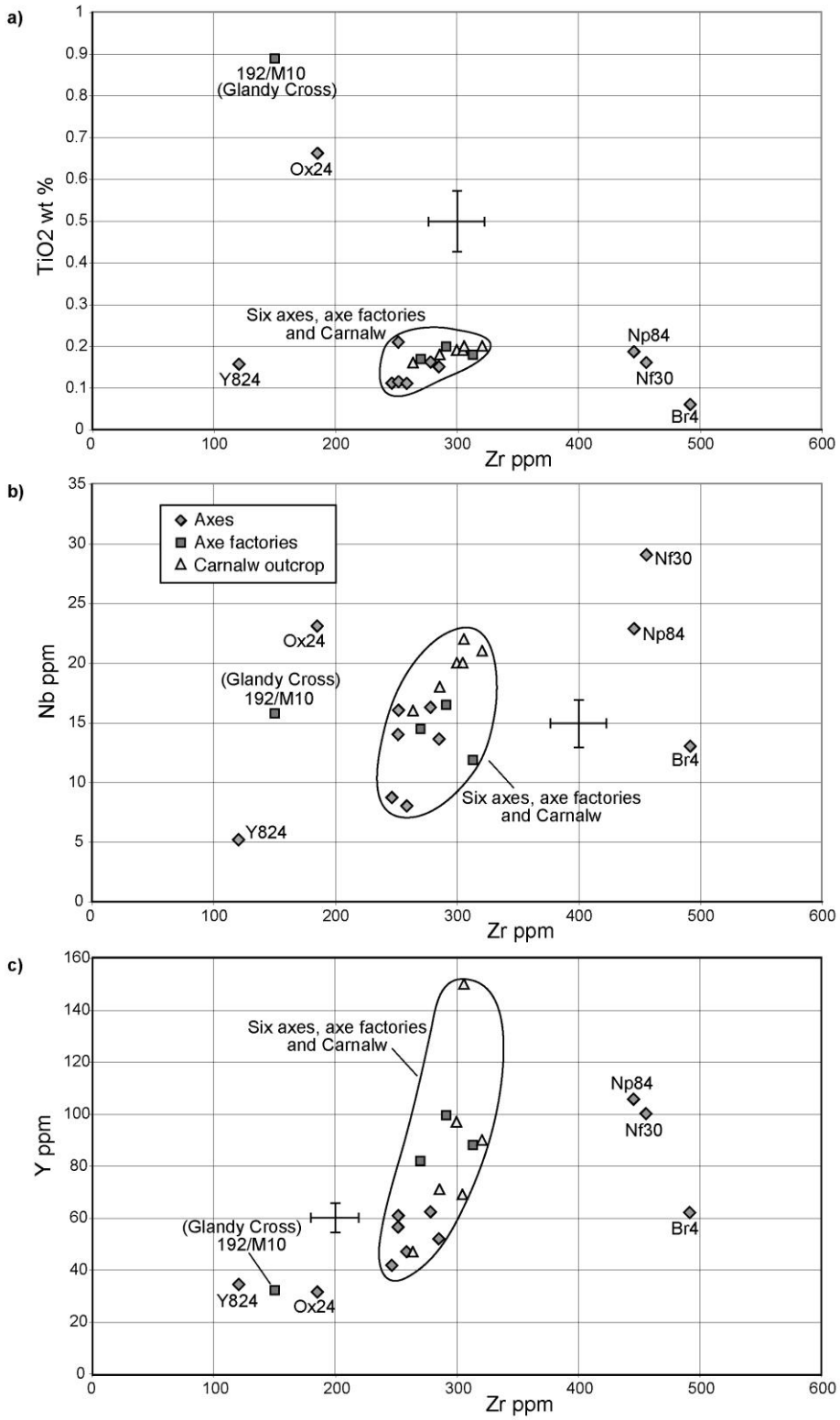

Figure 2. Graphs of (a) TiO_2 vs Zr, (b) Nb vs Zr and (c) Y vs Zr concentrations in analysed axes and axe factory material (Glyn-y-Fran and Glandy Cross) illustrating the compositional similarities discussed in the text. Data sources are as in Table 2. Error bars are based on average relative standard deviation (rsd) on repeat axe analyses (10% for TiO_2, 7% for Zr and Y, 13% for Nb). Uncertainties on other data (from laboratory XRF) are lower, at between 1–6% rsd. Data for Carnalw outcrop from Thorpe et al. *(1991). Ellipses enclose groups of samples as discussed in the text and have no statistical significance. Note that Carnalw outcrop samples include a large range of Y concentrations (2c).*

The studied axes

Table 1 lists the studied axes, giving details of their find sites, current whereabouts and descriptions. Figure 1 shows the locations of the axe find sites within the broader distribution of Group VIII artefacts established by the IPC (Clough & Cummins 1988, 272). The selection of these particular axes was based on practical issues (availability, and suitability for the analytical method used as discussed below) and does not represent any particular type, date, or geographical area. All the analysed axes have been thin sectioned by the Implement Petrology Committee (cf. Clough & Cummins 1988) and were regarded as conforming completely or (in two cases, noted in Table 1) "nearly" to the Group VIII type.

Geochemical characterisation

Geochemical analyses (Table 2) were determined using the non-destructive technique of portable X-ray fluorescence analysis (PXRF; method and applications in Potts *et al.* 1995, and Williams-Thorpe *et al.* 1999 respectively). PXRF analysis of unprepared archaeological artefacts can be significantly affected by weathered surface layers present on the artefacts (Potts *et al*. 2006). Therefore, axes that were obviously weathered (with, for example, a thick whitish or pale surface layer) were avoided for this work and only those with no visible, or only a very thin (less than 1 mm) weathered layer were analysed, taking care to analyse only the freshest-looking surface areas.

Comparison with Glyn-y-Fran and Glandy Cross

Geochemical data for rhyolitic material from Glyn-y-Fran and Glandy Cross were reported by Williams-Thorpe in David and Williams (1995 Appendix 1) and are included in Table 2 above for comparison with axe analyses. Two different rhyolitic rock types were identified at the axe factories: the first is present both at Glyn-y-Fran and Glandy (samples 226/F4H5, CRY1 and 190/N11 in Table 2); the second is represented by a single sample from Glandy Cross (192/M10).

Examination of the data in Table 2 shows marked similarity between the first six axes listed, and the first three axe factory samples, for almost all the elements analysed. Only Y is (systematically) lower in axes (analysed by PXRF) than in the factories (WDXRF analyses); Potts *et al.* (2006, 17 in table 5) noted some evidence for surface depletion of Y in PXRF analysis, possibly through weathering processes. The high Pb concentrations recorded for the axes (but not for the factory material) may be due to contamination of external surfaces of axe-heads as a result of anthropogenic factors (automobile exhaust emissions) acting since their recovery or excavation (discussion in Potts *et al.* 2006). An alternative explanation for elevated Pb values may be the effect of mineralization of the source rocks (information from anonymous referee; see also Cameron 1988 on Pb mineralization in Preseli area rocks); however, the persistence of high Pb concentrations in several axe groups when analysed by PXRF (Williams-Thorpe *et al.* 2003; Williams-Thorpe *et al.* 2004) tends to support the more generally applicable thesis of anthropogenic contamination. Either way, the Pb data are less useful for our case.

The remainder of the studied axes do not match the tight compositional grouping of the first six. Ox24 shows some similarity to factory sample 192/M10 (Glandy Cross). Nf30 and Np84 are similar to one another for all analysed elements and could be from a single rock outcrop. Y824 is not similar to any other of the studied axes. Br4, again, is of a different composition.

These similarities and differences are illustrated in Figure 2, where Ti, Zr, Y and Nb, (elements regarded as mainly immobile and therefore useful in characterisation and provenancing of rocks; e.g. Rollinson 1993) are plotted for the axes and axe factory samples (the figure also includes data for Carnalw outcrop, discussed below).

CONCLUSIONS AND DISCUSSION

Close geochemical similarities point to the likelihood that six out of eleven analysed Group VIII axes were made at the axe manufacturing sites in South Wales at Glyn-y-Fran and Glandy Cross (though it is also possible that they were made from equivalent material elsewhere). A seventh axe, Ox24 from Culham, may be made from a different rhyolitic type identified at Glandy Cross.

Provenancing of axe-heads to a (geographically remote) factory site carries the implication of human transport or trade of those axes away from the factory site, rather than transport of the raw material to find sites through a natural agency such as glaciation. Figure 1, above, shows the find locations of the axes, highlighting those seven that are associated with the Welsh axe factories. The distribution of these seven axes extends from Wales in the west, through central and southern England, to East Anglia, and is mainly inconsistent with a hypothesis of glacial transport away from a source in the Preseli area near the factory sites (compare inset on Figure 1; the Barry axe Gl14 is an exception and does lie on glacial trails from Preseli across South Wales).

The four axes that are not matched to the factory sites have not been provenanced in this work. Br4 was likened in previous work to outcrops on the north and west Pembrokeshire coast (Williams-Thorpe *et al*. 1999, 234).

The original outcrop source of the (glacially deposited, and now mostly heavily weathered) raw material utilised at Glyn-y-Fran and Glandy Cross has been suggested as Carnalw (marked on Figure 1) (Williams-Thorpe in David & Williams 1995 Appendix 1) on the basis of immobile trace element data and comparative source differentiation described in Thorpe *et al.* (1991). Analytical data for Carnalw can be compared with axes and factory samples on Figure 2 above. However, recent petrographic evidence does not support the Carnalw link. The spherulitic re-crystallisation texture that is most characteristic of Carnalw (Ixer & Bevins 2010, 11) is absent in the axe factory material (Rigby, and Jenkins, in David & Williams 1995, Appendices 2 and 3, respectively), and two axe factory thin sections examined recently by Dr R Bevins differ markedly from the Carnalw sections available for comparison and so were regarded as not originating at Carnalw (Bevins pers. comm. 2010). Yet, Carnalw is texturally very variable and contains non-spherulitic parts (Evans 1945, 97-98 and plate III; Thomas 1923, 249 and Plate XXIII) so it may be premature to dismiss this outcrop as the potential source of one part of the Group VIII assemblage.

A marked compositional feature of the axe factory material and analogous axes is the extremely low concentrations of certain mobile elements, in particular K, Rb and Ba (cf. Table 1), possibly depleted from original compositions as a result of earlier hydrothermal alteration of the rock. Similarly extreme compositions have been recognised elsewhere in South Wales, west and south-west of Preseli, within the Roche Rhyolite Group and at Rosebush within the Trefgarn and Sealyham Volcanic Groups (discussed by Thorpe *et al.* 1991, 130–132). However immobile element concentrations for these outcrops are not similar to the axes and factory material (data in Thorpe *et al.* 1991 Figures 11–13).

Further petrographic and geochemical study of Carnalw, concentrating on non-spherulitic, and also altered, material, together with a larger program of analysis of both axes and factory material for Group VIII, is now needed to resolve the question of original source outcrop(s) for Group VIII artefacts.

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