BRITISH GEOLOGICAL SURVEY

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MINERAL RECONNAISSANCE PROGRAMME
OPEN FILE REPORT NO. 14

GEOCHEMICAL SURVEYS FOR GOLD IN THE BERWYN HILLS

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This data package relates to work carried out by the British Geological Survey on behalf of the Department of Trade and Industry.

INTRODUCTION

During a reconnaissance drainage survey of the Berwyn Dome gold (Au) was identified in a panned concentrate from the Afon Trystion near Cynwyd (Figure 1). Additional panned concentrates collected upstream and analysed for Au and the gold-pathfinder element, arsenic (As), revealed the presence of an anomalous but irregular dispersion train over much of the Afon Trystion and its headwater tributary, the Nant y Lladron (Cooper et al., 1984).

The area was subsequently resampled by the Geochemical Survey Programme (GSP) in 1989 as part of the systematic regional geochemical mapping of the Mid Wales and Marches 1:250,000 map sheet. During the course of this work, gold was seen in panned concentrates collected from the lower reaches of the Afon Llynor the catchment to the south of the Afon Trystion, and from a small stream 2 km north east of the village of Glyndyfrdwy (Figure 1).

This open file report gives the results of detailed follow-up geochemical surveys designed to provide further information on the source of the gold discovered in the Afon Trystion and adjacent catchments by the MRP and GSP regional scale surveys.

The surveyed area is situated in Central Wales at the north west margin of the Berwyn Hills, approximately 15 km west of the market town of Llangollen and 3 km south of Corwen (Figure 1). Most of the area is hill land rising to a little over 600 m, supporting sheep grazing, grouse moor and, in the lower reaches of the main streams, coniferous forest plantations. Acid soils are developed over glacial (largely till) deposits with upto 2 m of peat on the highest ground. Rock exposure is restricted largely to stream courses and outcrops on interfluvial ridges.

GEOLOGY

The geology of the surveyed area is shown on the British Geological Survey, 1:50 000 scale, sheets 120, 121, 136, and 137 and was summarised recently by Duff and Smith (1992). The greater part of the area is composed of a thick succession of Ordovician (Caradoc-Ashgill age) mudstones and siltstones with subordinate sandstones, black shales and pyroclastic deposits which form distinctive marker horizons. Deposition of the sediments is considered to have occurred under low energy, shallow marine conditions on a lower shore face or inner shelf environment within the Welsh Basin (Brenchley and Pickerill, 1980). The two principal pyroclastic units (Swch Gorge Tuff and Pandy Tuff) are ignimbrite deposits with associated volcaniclastic sediments. They are of Caradoc age and may have been deposited subaerially in part, although the enclosing sediments are of shallow marine origin (Brenchley, 1978).

The oldest rocks, of Caradocian age, are exposed in the southernmost headwaters of the Nant y Lladron and much of the southeastern part of the survey area. Siltstones predominate with sporadic tuffs and ignimbrites (the Bryn, Teirw, and Pen Plaenau Siltstone Formations) succeeded by a distinctive dark grey graptolitic shale (the Blaen y cwm Shale Formation.). In the lower parts of the Afon Trystion, Nant y Lladron and Afon Llynor, sedimentary rocks of Ashgill age, notably

lacking in tuffs and volcaniclastics, overlie with marked unconformity the Caradoc sequence. The Ashgill rocks comprise cleaved micaceous siltstones with thin sandstone and dark mudstone bands (Dolhir Formation). In the Corwen area this formation is represented by both bedded and massive grits with thin interbedded mudstones .

The rocks of the Berwyn Hills form a structure which is considerably more complicated than the name Berwyn Dome implies. There is a succession of sub-parallel to en echelon arcuate flexures in which two major anticlines are separated by a more gentle syncline. Defomation is more intense on the southern limbs which may be vertical to overturned and sheared, possibly passing down into high angle reverse faults. North westerly directed compression of the sedimentary sequence in the Caledonian orogeny caused the deformation and also gave rise to steeply dipping pervasive cleavage. The most prominent fault, the north east - trending Bryn Eglwys fault follows the line of the River Dee betwen Cynwyd and Corwen. It represents an extension of the Bala Fault system to the south west, both structures probably occupying the sites of earlier extensional faults with dominantly vertical movements (Campbell, 1984).

GEOCHEMICAL SURVEY

Sampling

An integrated drainage, soil and rock sampling programme was undertaken in July 1992. Panned concentrate samples were collected from 79 stream sites in the Afon Trystion and adjacent catchments. Stream sediments, wet screened at 150 microns, were also taken at these sites. A 25 kg bulk sample of -2 mm stream sediment was collected for size fraction analysis and mineralogical examination from a site (RC 50) in the lower part of the Afon Trystion catchment (Figure 2). At approximately 30 % of sites an additional stream sediment sample screened at 63 microns was taken to establish whether gold was present in the silt and clay grade fraction. A regular sampling interval of about 200 m was adopted throughout the Trystion catchment, but elsewhere the interval was of the order 500 - 1000 m (Figures 1 and 2). Concentrates were obtained by panning an initial volume of 4 litres of -2 mm sediment to a final volume of about 75 ml, and stream sediments were prepared by wet sieving using standard BGS techniques. Ten panned concentrates, including all those in which gold was identified at site, were submitted for mineralogical examination. A total of 96 B-horizon soils (c. 200 g) were collected on traverses (50 m sample interval) around the head waters of the Nant y Lladron (Figure 2) using hand augers. Twenty rock samples (c. 2 kg) of representative lithologies, together with samples of mineralised float and till boulders were collected from stream bank and other exposures.

During the course of the survey a brief visit was made to the old Pb-Zn workings at Llangynog, about 14 km south of the Afon Trystion, to collect samples for precious metal and cadmium analysis. Samples of vein mineralisation were collected from outcrop and the dumps of the Craig Rhiwarth (RCR 106 and 107) and Llangynog (RCR 103 and 104) lead mines, and from the Nant y Blaidd trial (RCR 112, 113 and 114) which reputedly contained 2 oz/ton of gold in vein material (Foster-Smith, 1978). Heavy mineral concentrates derived by panning mine waste material were

collected from the dumps of the two mines, Craig Rhiwarth (RCP 44) and Llangynog (RCP 26), and from the stream draining the Nant y Blaidd trial (RCP 85 and 86).

Following milling and sub-sampling all samples were analysed for As, Cu, Zn, Sn, Sb, Pb, and Bi by X-ray fluorescence spectrometry in the BGS analytical laboratories. Cd was determined by the same method in rock samples and panned concentrates from mine sites in the Llangynog area. Au was determined in all samples by Acme Analytical, Vancouver, using a hot aqua regia digestion on 20 g powder splits followed by extraction with MIBK and a graphite furnace atomic absorption spectrophotometry finish.

Results

Analytical data are listed in Tables 1 - 6. Values reported below the detection limits are included and the data truncated at 0 ppm for XRF data and 1 ppb for gold.

Site inspection of panned concentrates confirmed the earlier observation of gold in the Afon Trystion. Small grains (maximum diameter 1.09 mm) were identified in concentrates from five sites (RC 2, 16, 50, 58, 75,) and removed for mineralogical examination. With one exception (RC 58) these were collected downstream of the small reservoir in the lower reaches of the stream (Figure 2). Estimates of gold concentration (in parenthesis) based on optical measurement of grain dimensions preceed the analytical values for the panned concentrates (Table 1). Owing to the small surface area of the grain recovered from RC 50 a reliable estimate of gold concentration was not possible at this site. In the lower part of the catchment, a few highly anomalous Au values (maximum 8200 ppb) were obtained from samples in which there was no visible gold. This suggests that either some gold may be too fine to be visible, or that it is present as inclusions in coarse pyrite grains noted in many of the concentrates. The former suggestion is considered unlikely, as Au values for the -150 μm, -63 μm sediment fractions and for samples from which visible grains had been removed are consistently low (Tables 2 and 3).

Although As values are markedly higher in the survey area compared to the regional background (Cooper et al., 1984), the various drainage sample media show little direct correlation between As and the high levels of Au recorded in panned concentrates from the lower section of the main stream. The highest levels of As in panned concentrates occur in the south eastern headwater of the Nant y Lladron, whilst stream sediments are most enriched in the south western branch of the Nant Croes y Wernen. Particularly abundant deposits of recently precipitated iron oxide suggest that the As concentration is mainly a result of hydromorphic processes in the Nant Croes y Wernen, although a mineralised source may exist in the peat covered area between the two catchments. An extensive linear zone of quartz (vein) boulders occurs at surface in the interfluve area, but no evidence of mineralisation or country rock fragments indicative of shearing was found in these.

Only one visible occurrence of gold in panned concentrates was noted in the Nant y Lladron (RCP 58). However, locally high analytical Au values (RCP 60 contains 5770 ppb) in conjunction with elevated As (up to 160 ppm), and Sb (up to 6 ppm) define a zone of elevated metal values extending southwards from RC 60 for about 500 m. The source of this dispersion train may lie in drift or underlying rocks to the south west as soil samples (RCS 248-251) collected from a NW - SE

traverse along the valley side contain weakly anomalous levels of Au and common pathfinder elements (Sb, As, and Bi). Other indications of mineralisation in the near vicinity include two sheared mudstone clasts from an exposure of till in the most easterly headwater of the Nant y Lladron (RCR 108 and 118). Secondary copper minerals were noted in these samples and their enhanced levels of Cu, Sb, As and Ag may explain the presence of the downstream drainage anomaly. Samples of panned till from this locality also contain weakly anomalous levels of Sb and Au.

The results of the mineralogical examination of gold grains from the Afon Trystion and Glyndyfrydwy catchments are described in the BGS, Mineralogy and Petrology, Short Report No. MPSR/93/4 (Appendix). Two distinct morphological types of gold were identified, indicating both local and more distant provenance. A common source of both is indicated by similarity of silver concentrations in them. Mercury is concentrated in the rim of one grain from site RC 75, and it is suggested that this could be caused by previous Au mining activity in the area. However, there are no records of such activity and no evidence of past mining was seen in the catchment during the field survey.

Data for the mineralised rock and panned concentrate samples from the Llangynog Pb-Zn mine dumps (RCR 103, 104, 106, 107; RCP 26 and 44) contain only minor enrichment of Au, Ag, Sb, Cd and Bi (Tables 1 and 6).

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FIGURES

TABLES

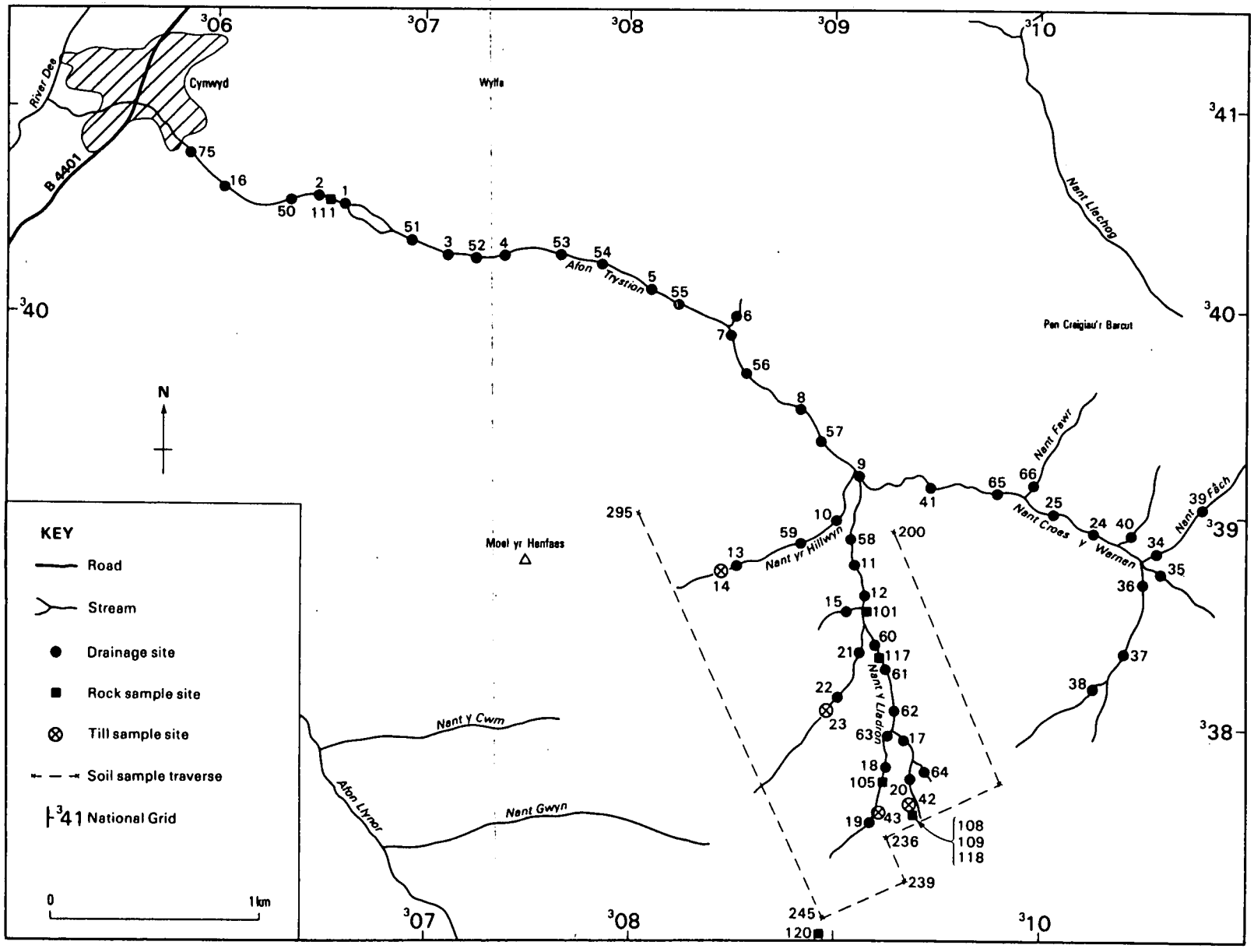

Figure 2 : Location of drainage, till, rock and soil sample sites in the Afon Trystion catchment

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Berwyn Hills Panned Concentrate Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Cd (ppm)	Pb (ppm)	Bi (ppm)
RCP1	306620	0340529	1	24	14	177	7	0.0		60	1
RCP2	306460	0340560	(13400)3	32	21	165	0	0.0		31	2
RCP3	307118	0340265	2	41	27	190	0	0.0		44	0
RCP4	307423	0340260	8200	19	17	150	0	0.0		32	0
RCP5	308034	0340185	11	30	19	168	0	0.0		31	1
RCP6	308500	0339920	1	9	7	113	5	2.0		35	0
RCP7	308480	0339880	2	38	25	193	0	3.0		40	0
RCP8	308800	0339540	3	41	23	176	0	2.0		69	0
RCP9	309130	0339180	2	55	23	183	0	2.0		31	0
RCP10	309010	0339060	1	13	10	103	1	0.0		17	0
RCP11	309090	0338780	4	83	30	186	6	7.0		33	0
RCP12	309130	0338660	3	91	31	188	4	5.0		41	1
RCP13	308542	0338770	1	11	7	94	3	1.0		14	0
RCP15	309080	0338550	1	22	15	100	0	0.0		15	0
RCP16	306030	0340615	(1460)2	28	71	202	198	0.0		439	1
RCP17	309300	0337960	7	160	48	206	0	8.0		50	1
RCP18	309239	0337800	4	62	23	152	1	1.0		25	0
RCP19	309180	0337620	2	34	18	139	0	4.0		31	0
RCP20	309079	0337810	8	130	47	178	0	6.0		41	0
RCP21	309115	0338420	1	23	10	120	0	1.0		26	0
RCP22	309040	0338180	1	31	15	153	0	0.0		22	1
RCP24	310295	0338922	1	28	15	111	1	0.0		18	0
RCP25	310060	0339040	1	24	12	123	0	0.0		20	1
RCP26	305320	0325620	9	14	4038	>100000	15	85.0	101	>100000	83
RCP27	307380	0338005	1	21	11	194	4	0.0		33	0
RCP28	307540	0337590	3	14	14	149	0	1.0		16	0
RCP29	306015	0338220	1	22	22	165	0	0.0		32	1
RCP30	304960	0338100	1	26	29	173	5	0.0		42	0
RCP31	305330	0338080	1	23	21	170	7	0.0		20	0
RCP32	306820	0337398	1	17	20	163	0	0.0		31	0
RCP33	306880	0337460	2	17	15	174	9	0.0		28	0
RCP34	310522	0338800	1	27	16	212	0	0.0		22	0
RCP35	310550	0338760	1	16	10	110	2	2.0		20	0
RCP36	310499	0338720	1	25	11	103	1	0.0		15	0
RCP37	310420	0338385	1	43	10	113	0	0.0		22	1
RCP38	310290	0338180	1	14	12	104	1	0.0		10	0
RCP39	310770	0339020	1	20	16	178	0	1.0		34	0
RCP40	310420	0338900	1	7	7	92	2	0.0		26	0
RCP41	309490	0339165	1	29	13	144	0	0.0		50	0
RCP44	305400	0326380	11	4	2906	>100000	8	192.0	135	>100000	91
RCP45	306290	0337270	1	43	30	146	1	1.0		51	0
RCP46	307230	0336880	1	15	18	135	0	1.0		43	0
RCP47	311408	0335880	1	22	18	114	1	1.0		28	0
RCP48	312500	0335682	1	22	18	135	4	2.0		226	0
RCP49	313075	0335830	1	34	27	186	2	0.0		43	0
RCP50	306310	0340540	4	26	63	165	341	1.0		108	0
RCP51	306936	0340360	1	29	21	181	0	0.0		26	2
RCP52	307250	0340280	5380	26	18	153	0	0.0		31	0

Table 1

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Berwyn Hills Panned Concentrate Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Cd (ppm)	Pb (ppm)	Bi (ppm)
RCP53	307640	0340282	38	38	19	175	0	0.0		29	2
RCP54	307878	0340243	2	24	16	151	0	1.0		26	1
RCP55	308240	0340060	2	37	24	177	0	0.0		50	0
RCP56	308590	0339660	1	46	27	174	3	0.0		87	0
RCP57	308910	0339390	2	50	27	182	2	0.0		34	1
RCP58	309060	0338920	(935)9	74	30	208	10	1.0		41	0
RCP59	308880	0338880	1	8	576	110	0	2.0		39	0
RCP60	309167	0338440	5770	122	42	212	0	5.0		69	0
RCP61	309260	0338282	13	100	37	192	13	1.0		34	0
RCP62	309280	0338080	5	102	44	187	0	3.0		68	0
RCP63	309260	0337960	4	73	27	175	0	3.0		32	1
RCP64	309430	0337830	1	50	16	102	3	4.0		20	0
RCP65	309760	0339130	1	28	15	132	0	0.0		23	0
RCP66	309930	0339145	1	13	13	233	0	0.0		12	0
RCP67	310240	0336300	1	18	15	108	3	5.0		15	0
RCP68	316635	0337485	1	21	17	153	0	1.0		30	0
RCP69	314360	0337145	1	42	18	176	3	5.0		88	0
RCP70	312010	0338340	1	26	13	97	0	2.0		26	0
RCP71	312160	0338830	1	39	15	135	0	0.0		29	0
RCP72	312138	0337685	1	38	17	112	0	0.0		62	0
RCP73	312140	0337450	1	47	12	124	1	0.0		24	0
RCP74	312900	0337175	1	44	9	106	0	0.0		25	0
RCP75	305900	0340760	(6280)2	24	16	183	42	0.0		103	0
RCP76	310240	0342990	1	27	48	695	0	0.0		57	0
RCP77	309840	0342050	1	15	12	103	0	0.0		68	0
RCP78	307790	0342960	1	18	13	206	4	0.0		16	0
RCP79	316180	0343660	1	10	25	166	15	5.0		725	0
RCP80	315930	0344920	1	13	24	224	33	0.0		78	0
RCP81	315760	0344650	1	4	21	133	127	0.0		55	0
RCP82	315860	0344330	1	12	16	139	21	0.0		82	0
RCP83	315940	0344020	1	10	17	148	114	1.0		296	0
RCP85	309080	0328340	1	12	84	536	9	0.0		728	0
RCP86	308960	0328150	1	14	21	156	26	0.0		90	0

Values in parenthesis represent estimated concentrations based on the dimensions of gold grains

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Berwyn Hills Stream Sediment Data (-150 micron fraction)

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCC1	306620	0340529	1	37	17	567	4	0.0	74	0
RCC2	306460	0340560	2	27	14	291	3	0.0	51	0
RCC3	307118	0340265	2	30	15	236	2	0.0	32	1
RCC4	307423	0340260	1	26	14	196	1	1.0	31	0
RCC5	308034	0340185	1	43	16	274	1	1.0	42	0
RCC6	308500	0339920	3	13	8	139	2	2.0	43	0
RCC7	308480	0339880	1	42	14	289	3	1.0	49	0
RCC8	308800	0339540	1	32	16	223	1	3.0	44	0
RCC9	309130	0339180	1	39	14	236	3	2.0	39	0
RCC10	309010	0339060	1	32	13	120	1	2.0	65	0
RCC11	309090	0338780	2	38	15	213	6	2.0	31	0
RCC12	309130	0338660	1	40	14	232	3	0.0	38	0
RCC13	308542	0338770	1	56	10	98	2	0.0	71	0
RCC15	309080	0338550	1	47	13	110	2	2.0	47	0
RCC16	306030	0340615	2	26	24	299	15	0.0	103	0
RCC17	309300	0337960	2	45	18	233	2	3.0	55	0
RCC18	309239	0337800	1	56	15	185	1	1.0	33	1
RCC19	309180	0337620	2	123	14	189	1	0.0	39	1
RCC20	309079	0337810	3	58	16	191	3	3.0	36	0
RCC21	309115	0338420	1	32	12	124	3	0.0	79	0
RCC22	309040	0338180	5	39	18	180	5	4.0	105	0
RCC24	310295	0338922	1	95	16	241	3	1.0	81	1
RCC25	310060	0339040	1	66	13	247	1	1.0	56	0
RCC27	307380	0338005	1	34	14	211	6	0.0	92	0
RCC28	307540	0337590	3	32	19	221	1	2.0	30	0
RCC29	306015	0338220	1	15	18	196	1	1.0	37	0
RCC30	304960	0338100	1	18	20	207	1	0.0	30	0
RCC31	305330	0338080	1	22	18	215	1	3.0	30	0
RCC32	306820	0337398	1	31	20	250	3	3.0	40	0
RCC33	306880	0337460	2	29	17	244	1	2.0	30	0
RCC34	310522	0338800	1	54	15	688	0	0.0	75	0
RCC35	310550	0338760	1	39	8	128	0	0.0	43	0
RCC36	310499	0338720	1	193	9	160	0	0.0	73	0
RCC37	310420	0338385	1	302	9	175	0	0.0	72	0
RCC38	310290	0338180	1	109	14	223	0	2.0	57	0
RCC39	310770	0339020	1	63	13	522	0	0.0	88	0
RCC40	310420	0338900	1	23	10	91	1	0.0	82	0
RCC41	309490	0339165	1	52	14	249	1	1.0	46	0
RCC45	306290	0337270	1	90	20	240	0	0.0	46	0
RCC46	307230	0336880	1	110	10	121	0	0.0	82	0
RCC47	311408	0335880	1	117	15	153	3	0.0	97	0
RCC48	312500	0335682	1	80	20	211	2	1.0	101	1
RCC49	313075	0335830	2	68	12	325	2	1.0	90	0
RCC50	306310	0340540	1	30	33	344	207	1.0	134	0
RCC51	306936	0340360	3	30	14	249	0	0.0	40	1
RCC52	307250	0340280	1	25	16	220	0	0.0	38	0
RCC53	307640	0340282	1	33	14	245	2	0.0	47	1
RCC54	307878	0340243	1	29	14	206	2	0.0	38	0

Table 2

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Berwyn Hills Stream Sediment Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCC55	308240	0340060	1	32	15	242	2	2.0	38	0
RCC56	308590	0339660	1	25	14	198	5	0.0	33	0
RCC57	308910	0339390	1	34	13	230	1	0.0	38	0
RCC58	309060	0338920	1	50	18	306	4	3.0	47	0
RCC59	308880	0338880	1	53	182	177	3	0.0	92	0
RCC60	309167	0338440	2	41	17	252	1	0.0	39	0
RCC61	309260	0338282	1	48	17	233	6	4.0	42	0
RCC62	309280	0338080	1	39	15	230	1	2.0	34	0
RCC63	309260	0337960	1	47	12	209	1	2.0	36	0
RCC64	309430	0337830	1	34	10	76	4	1.0	45	1
RCC65	309760	0339130	2	101	13	345	2	0.0	96	0
RCC66	309930	0339145	1	34	13	598	4	1.0	78	1
RCC67	310240	0336300	1	23	18	171	4	2.0	41	0
RCC68	316635	0337485	2	20	17	258	2	0.0	59	0
RCC69	314360	0337145	2	129	21	508	4	1.0	193	0
RCC70	312010	0338340	1	138	21	153	3	0.0	116	2
RCC71	312160	0338830	1	144	19	379	4	0.0	94	0
RCC72	312138	0337685	1	95	18	243	3	0.0	145	2
RCC73	312140	0337450	1	139	12	165	1	0.0	62	1
RCC74	312900	0337175	1	117	12	134	0	0.0	78	1
RCC75	305900	0340760	1	25	20	354	15	0.0	93	0
RCC77	309840	0342050	2	66	19	207	0	1.0	78	0
RCC78	307790	0342960	25	54	20	374	3	2.0	104	0
RCC79	316180	0343660	1	14	20	156	2	0.0	108	0
RCC82	315860	0344330	1	16	19	149	2	0.0	43	0

BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Berwyn Hills Stream Sediment Data (-63 micron fraction)

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCF11	309090	0338780	2	39	12	229	2	0.0	42	0
RCF12	309130	0338660	2	41	15	251	0	0.0	36	1
RCF13	308542	0338770	2	53	16	103	5	0.0	97	0
RCF15	309080	0338550	1	49	13	110	1	0.0	61	0
RCF16	306030	0340615	3	24	31	314	8	0.0	112	0
RCF18	309239	0337800	1	56	12	190	1	0.0	24	0
RCF20	309079	0337810	2	57	15	209	2	2.0	41	0
RCF21	309115	0338420	1	29	13	127	5	1.0	81	0
RCF29	306015	0338220	1	31	23	257	1	0.0	51	0
RCF32	306820	0337398	1	32	20	237	2	0.0	37	0
RCF34	310522	0338800	1	56	18	763	2	0.0	92	0
RCF35	310550	0338760	1	51	11	156	2	0.0	57	0
RCF36	310499	0338720	1	234	11	156	0	0.0	78	0
RCF48	312500	0335682	1	79	24	217	3	0.0	100	0
RCF50	306310	0340540	2	35	26	334	20	0.0	74	0
RCF58	309060	0338920	1	52	17	298	1	0.0	47	0
RCF59	308880	0338880	1	34	33	143	0	0.0	57	0
RCF60	309167	0338440	1	43	16	243	1	0.0	31	1
RCF62	309280	0338080	2	41	15	201	4	1.0	39	0
RCF65	309760	0339130	1	83	12	314	0	2.0	68	1
RCF66	309930	0339145	1	39	15	586	2	0.0	97	0
RCF67	310240	0336300	1	127	13	123	2	0.0	91	0
RCF68	316635	0337485	1	25	17	257	3	0.0	58	0
RCF70	312010	0338340	1	122	18	158	1	0.0	107	1
RCF73	312140	0337450	1	161	11	165	4	1.0	74	1
RCF79	316180	0343660	1	12	20	163	5	0.0	122	0
RCF82	315860	0344330	1	15	20	158	3	1.0	47	0

Table 3

BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Berwyn Hills Panned Till Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCU14	308538	0338730	1	29	18	99	0	2.0	23	0
RCU23	309035	0338180	2	64	34	116	0	2.0	34	0
RCU42	309355	0337680	10	72	54	123	1	9.0	45	0
RCU43	309220	0337650	6	61	29	147	0	7.0	35	0

Table 4

BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Berwyn Hills Soil Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCS200	309300	0338920	1	16	15	81	2	2.0	20	1
RCS201	309314	0338881	1	19	11	85	3	1.0	29	2
RCS202	309329	0338841	1	20	9	59	2	2.0	24	2
RCS203	309344	0338800	1	26	14	76	2	1.0	20	0
RCS204	309358	0338759	1	10	13	56	3	1.0	30	1
RCS205	309373	0338720	3	21	16	144	3	1.0	33	1
RCS206	309388	0338679	1	34	13	73	4	2.0	34	0
RCS207	309402	0338639	4	29	10	56	3	2.0	21	1
RCS208	309418	0338595	1	10	3	12	4	2.0	15	1
RCS209	309435	0338548	2	19	16	85	2	1.0	18	2
RCS210	309456	0338492	2	29	13	72	2	2.0	19	1
RCS211	309476	0338435	1	31	11	62	3	1.0	21	1
RCS212	309497	0338379	2	36	13	57	4	1.0	22	1
RCS213	309518	0338322	1	25	10	54	3	2.0	21	1
RCS214	309538	0338266	1	28	14	87	3	1.0	25	1
RCS215	309557	0338215	1	39	14	73	3	1.0	20	0
RCS216	309574	0338168	1	30	10	53	2	1.0	14	1
RCS217	309591	0338121	2	38	10	71	2	1.0	20	2
RCS218	309608	0338074	4	32	15	85	1	1.0	12	1
RCS219	309625	0338027	1	36	17	67	3	2.0	21	1
RCS220	309642	0337980	1	41	13	53	3	2.0	18	1
RCS221	309659	0337933	1	7	5	17	4	2.0	10	0
RCS222	309676	0337886	1	18	12	49	1	0.0	22	2
RCS223	309693	0337839	1	17	6	21	2	0.0	16	1
RCS224	309710	0337792	1	26	11	48	2	1.0	15	1
RCS225	309729	0337743	1	17	8	45	3	1.0	12	1
RCS226	309745	0337698	1	24	17	67	1	1.0	21	1
RCS227	309698	0337681	1	41	13	67	3	2.0	24	0
RCS228	309651	0337664	2	46	33	131	2	2.0	40	1
RCS229	309604	0337647	2	41	16	72	2	1.0	25	2
RCS230	309557	0337630	2	30	24	84	2	1.0	49	3
RCS231	309510	0337613	1	21	15	65	2	0.0	18	2
RCS232	309463	0337596	2	26	15	66	3	2.0	17	1
RCS233	309416	0337579	2	24	5	30	2	1.0	15	3
RCS234	309359	0337558	2	31	22	41	3	2.0	25	0
RCS235	309322	0337544	3	30	23	78	3	2.0	26	1
RCS236	309251	0337519	1	18	16	59	2	2.0	18	2
RCS237	309418	0338595	1	23	8	42	2	2.0	19	2
RCS238	309416	0337579	2	15	7	60	3	1.0	16	1
RCS239	309219	0337241	2	6	15	41	3	3.0	20	0
RCS240	309078	0337190	5	25	28	74	3	2.0	21	1
RCS241	309031	0337173	3	21	24	68	3	4.0	25	0
RCS242	308984	0337156	2	15	25	83	4	3.0	32	1
RCS243	308928	0337135	2	8	22	73	2	2.0	27	1
RCS244	308890	0337121	1	18	24	88	3	2.0	20	2
RCS245	308843	0337104	1	21	23	71	2	2.0	21	1
RCS246	308804	0337212	1	15	21	104	2	1.0	28	3
RCS247	308792	0337245	1	12	24	53	3	2.0	22	1

Table 5

BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Berwyn Hills Soi Data

Sample Reference	Easting	Northing	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Sn (ppm)	Sb (ppm)	Pb (ppm)	Bi (ppm)
RCS248	308775	0337292	1	15	21	74	2	4.0	27	3
RCS249	308758	0337339	14	29	24	57	2	8.0	32	0
RCS250	308739	0337391	4	55	32	62	3	29.0	28	0
RCS251	308724	0337433	1	44	16	49	2	7.0	17	1
RCS252	308707	0337480	1	35	18	65	3	3.0	18	0
RCS253	308707	0337480	2	29	16	84	1	2.0	20	0
RCS254	308690	0337527	1	38	14	49	2	2.0	16	1
RCS255	308672	0337574	1	34	19	68	2	3.0	22	1
RCS256	308672	0337574	2	30	23	86	2	3.0	23	1
RCS257	308655	0337621	1	37	10	50	2	1.0	20	0
RCS258	308638	0337668	1	37	17	56	3	1.0	25	0
RCS259	308621	0337715	1	23	18	81	3	2.0	18	2
RCS260	308604	0337762	1	21	13	72	3	1.0	20	3
RCS261	308587	0337809	1	16	8	51	2	1.0	21	0
RCS262	308570	0337856	1	34	12	58	3	3.0	23	0
RCS263	308553	0337903	1	27	14	75	3	1.0	19	3
RCS264	308536	0337950	1	17	15	77	4	1.0	18	1
RCS265	308519	0337997	1	18	12	61	3	2.0	21	1
RCS266	308501	0338044	1	23	10	50	3	2.0	21	3
RCS267	308484	0338091	1	19	13	51	2	1.0	19	2
RCS268	308467	0338138	1	30	13	53	3	2.0	28	1
RCS269	308450	0338185	1	30	13	65	2	1.0	23	4
RCS270	308433	0338232	1	23	7	37	2	0.0	11	1
RCS271	308416	0338279	1	33	24	72	2	1.0	38	1
RCS272	308399	0338326	1	32	11	63	1	1.0	13	2
RCS273	308382	0338373	1	33	14	63	2	1.0	17	0
RCS274	308365	0338420	1	18	8	44	2	0.0	11	1
RCS275	308348	0338467	1	35	14	52	2	2.0	31	1
RCS276	308330	0338514	1	28	13	61	1	0.0	20	2
RCS277	308313	0338561	1	35	12	37	2	1.0	28	1
RCS278	308296	0338608	1	35	11	37	2	1.0	23	2
RCS279	308279	0338655	1	23	11	75	2	0.0	21	1
RCS280	308262	0338702	1	19	18	88	1	1.0	28	0
RCS281	308241	0338758	1	9	16	96	1	0.0	13	1
RCS282	308224	0338805	1	25	11	59	1	1.0	21	0
RCS283	308207	0338852	1	21	14	70	1	1.0	20	1
RCS284	308190	0338899	1	19	11	64	2	1.0	18	2
RCS285	308173	0338946	1	20	9	31	1	2.0	33	2
RCS286	308156	0338993	1	18	13	48	1	1.0	18	1
RCS287	308125	0339078	1	15	9	36	3	1.0	18	0
RCS288	308091	0339172	1	18	9	40	2	1.0	14	0
RCS289	308057	0339266	1	20	13	58	1	0.0	19	0
RCS290	308023	0339360	1	23	14	70	1	1.0	19	1
RCS291	307988	0339454	1	18	12	45	1	1.0	10	0
RCS292	307954	0339548	1	18	13	69	1	0.0	24	1
RCS293	307920	0339642	1	18	10	61	1	1.0	17	1
RCS294	307886	0339735	1	21	10	44	2	1.0	13	0
RCS295	307852	0339829	1	22	11	87	3	2.0	24	0

BRITISH GEOLOGICAL SURVEY
Mineral Reconnaissance Programme

Berwyn Hills Rock Data

Sample Reference	Easting	Northing	Major rock type	Au (ppb)	As (ppm)	Cu (ppm)	Zn (ppm)	Ag (ppm)	Sb (ppm)	Cd (ppm)	Pb (ppm)	Bi (ppm)
RCR101	309120	0338580	4900	7	18	6	19	1	0	1	2	0
RCR103	305520	0325640	4900	6	0	675	>10000	38	226	1343	>10000	34
RCR104	305520	0325640	4900	6	45	1410	13102	8	41	139	10095	5
RCR105	309230	0337780	3S00	1	16	26	165	5	0	1	30	0
RCR106	305400	0326450	4900	140	0	7742	>10000	105	683	348	>10000	187
RCR107	305400	0326560	1ABH	18	26	103	7521	13	89	33	>10000	15
RCR108	309355	0337680	4900	2	57	97	69	6	1	1	13	0
RCR109	309370	0337700	3800	1	35	113	107	4	7	0	13	0
RCR110	311200	0335920	1JG0	1	2	5	70	0	0	0	17	0
RCR111	306520	0340560	3L00	1	8	12	80	2	1	0	14	0
RCR112	308970	0328140	3S00	1	29	4	0	0	0	0	29	0
RCR113	308970	0328140	4900	1	14	13	17	0	1	0	114	0
RCR114	309080	0328380	2L00	3	14	10	34	3	4	0	26	0
RCR115	316020	0344840	3L00	2	15	33	156	3	0	1	20	0
RCR116	307220	0336820	1JD1	1	0	9	36	0	0	1	21	0
RCR117	309210	0338360	3L00	1	5	112	99	1	0	1	52	0
RCR118	309355	0337680	3S00	8	61	92	66	3	39	0	8	2
RCR119	310240	0343000	3L00	2	9	19	52	0	1	1	10	0
RCR120	308930	0336900	3L00	3	9	17	115	4	3	0	11	0

Table 6

BRITISH GEOLOGICAL SURVEY

Mineralogy and Petrology

Short Report MPSR/93/4

Gold from panned concentrates from the Berwyn Dome,Clwyd.

Examination requested

Ten panned concentrates, together with four size fractions from a large sample (RC50a & b) were received for the recovery of gold.

Laboratory examination

The panned concentrates were sieved and the <500 micron fraction superpanned. The dense material from the superpanner was separated into five fractions of different magnetic susceptibility with a Franz Isodynamic magnetic separator and then examined for gold. After the gold (and some grains for identification eg. possible monazite) had been removed from the fractions, they were recombined and passed to the Analytical Group for analysis.

The sieve fractions from the bulk sample (and the resieved duplicates) 500-250 microns, 250-120 microns and 120-63 microns were superpanned. The <63 micron fraction was hydrocycloned to concentrate the heavier and larger grains before superpanning. Gold and a few other grains were removed for examination.

All the extracted gold grains were, where possible, weighed and their size and area measured with the Kontron Image analysis system. The compositions of a point on the external surface of each gold grain (in its as discovered form) was measured (with the Cambridge Microscan V Electron Microprobe and its Link Systems EDS attachment). The other grains removed from the concentrates were identified. One grain thought to be gold proved to be brass.

Six of the gold grains (the larger ones, from RC2, 16, 50, 58 and two from 75) were mounted in resin on a glass slide and polished to reveal a cross section through the grains.

The polished surfaces were analysed in the Cambridge Electron Microprobe and some microchemical maps prepared with the Cameca SX50 Electron Microprobe.

Results

Examination of the polished surfaces of the gold grains with a petrological microscope showed that the cores of the grains were relatively silver-rich but contained much richer "tracks". Thin gold-rich rims were present although not completely enclosing the core and in places this purer gold penetrated the grains.

The analyses (both external surface and polished cross-section), together with area, dimensions and weights of the eight gold grains are given in the table below.

The microchemical maps are presented in the plates. These show a rainbow scale proportional to concentration. They have been enhanced for clarity,

Point Analyses

Analyses on the Rough Surface of the Grains

	Au	Ag	Hg	Fe	As	Area sq mm	Dmax mm	Dmin mm	Weight mg
RC02	83.4	10.5	0	0	0	0.527	1.09	0.66	0.91
RC16	94.3	0	2.1	0	0.2	0.196	0.68	0.4	0.23
RC50/1	95.7	0.7	0	0	0	0.0971	0.42	0.34	
RC58	93.4	2.7	0	0.5	0	0.181	0.78	0.36	0.13
RC75/1	76.6	0	16	0	0	0.33	0.71	0.6	0.91
RC75/2	97.2	0	1.8	0	0	0.212	0.6	0.51	in above
RC80	95.6	1.8	0	0	0	0.0348	0.25	0.2	
RC82	86.3	5.3	0	0	0	0.0231	0.21	0.17	

Analyses on Polished Grains

	Au	Ag	Hg	Pb
RC02 core	85.3	15.6		
RC02 rim	87.8	7.06		
RC16 window	88.8	12.1		
RC50 core	89.8	11.8		
RC50 rim	87.8	7.06		
RC58 window	85.5	12.1		
RC75/1 core	85.8	15.6		
RC75/1 rim	91.5	3.8	2.61	1.17
RC75/2 core	83	17.9		
RC75/2 rim	96.8	1.12	2.13	

red, the highest concentration, corresponds closely to 100% for the gold maps. For the silver maps it corresponds to about 50% (RC2) or 30% (RC75/1 and 75/2). For the mercury map it is probably less than 10%. In the maps the silver-rich tracks are clearly seen, as is the gold-rich rim which is penetrating into the grain in each set of maps. The mercury, which was only detected in the maps of RC75/1, is seen to be restricted to the gold-rich rim.

The following identifications of the extracted grains were made with the Electron Microprobe

Sample Number	Mineral
RC002	Galena
RC016	Iron Silicate, Cassiterite, Monazite
RC050a	Monazite, Lead glass/glaze, Solder, Brass
RC058	Monazite
RC080	Galena
RC082	Cinnabar

Comment

Several of the gold grains are flattened, fairly smooth with scratch marks and with indications of folding suggesting much transport (RC002, RC016 & RC058). Others are knobbly with attached ?quartz, indentations and showing crystal faces (dodecahedron form common for gold) indicating a short residence/transport in the stream (RC50b +250μm , RC075, RC080 & RC082).

The presence of mercury, which is mainly associated with the knobbly grains, could indicate the existence of previous mining as mercury is often used to concentrate gold by amalgamation and often escapes into the river.

The core analyses range from 12.1% to 17.9% Ag with a median of 15.4% Ag. This is a tight enough distribution to suggest a common source.

The silver tracks, which may be sub-grain boundaries, indicate that some process of thermal or mechanical stress changes may have taken place at low temperatures (gold and silver are completely miscible at high temperatures) to cause the migration of silver to these crystallite boundaries. In the microchemical map for silver of RC75/2 the core is divided into five regions by the tracks. The lowest region can be seen to contain slightly less silver than the others, about 5% lower since the average pixel values are 75 and 79 in two representative areas. However the differences are probably not statistically significant.

D.J.Bland
29-01-93