Excursion 6 Silver Glen, Alva

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Purpose: To illustrate the historically important metalliferous mines of the Silver Glen, Alva. Hosted in the volcanic rocks of the Ochil Volcanic Formation (Arbuthnott–Garvock Group), the mineral veins were made famous by the occurrence of native silver and cobalt ore.

Logistics: Silver Glen may be reached from Stirling by the A91 to just east of Alva, turning northwards (left) towards Burnside [NS 8925 9695] to the car and coach park at the Ochil Hills Woodland Park [NS 8985 9750]. Toilets are available in Alva. Waterproof footwear with good grip is essential. Walking is on tracks and paths.

Maps: OS 1:50,000 Sheet 58 Perth & Alloa; OS 1:25,000 Sheet 366 Stirling & Ochil Hills West; BGS 1:50,000 Sheet 39E Alloa; locality map (Figure 6.1).

Metalliferous mineralisation in the Ochil Volcanic Formation was exploited in the Alva area intermittently from the seventeenth to the nineteenth centuries at numerous small mines, many of which were little more than trial adits into steep valley and hill sides. This is particularly true of many small baryte veins in the area, where trial workings probably represent unsuccessful prospects for copper or silver. By far the most successful workings were in the Silver Glen (Plate 6.1), a little to the NE of Alva, where mineralisation was first discovered in 1711. These workings provided most of the silver produced from the area in the early eighteenth century. Records suggest that this amounted to at least 45 tonnes of ore assaying 85% Ag. Furthermore, a substantial amount of cobalt ore (clinosafflorite, (Co, Fe, Ni)As2) was produced from the Alva Silver Glen workings and earlier spoil heaps for use in the pottery industry, following its first recognition in 1759. A detailed account of the mineralisation in the Alva area is available (Francis *et al*., 1970; Hall *et al*., 1982; Dickie & Forster, 1994).

Two main groups of workings can be recognised, depending on whether (a) silver was produced or (b) other metals such as copper, iron or lead were exploited, as follows:

Mine Locality	**National Grid Reference (NS)**
a. Silver Producers	
Airthrey	[NS 815 972]
Alva	[NS 891 977]
Carnaughton	[NS 878 975]
Tillicoultry	[NS 912 978]
b. Producers of other metals	
Airthrey Hill	[NS 795 978]
Allan Water	[NS 787 983]
Alva	[NS 891 977]
Jerah	[NS 832 995]
Tillicoultry (Daiglen)	[NS 911 983]

It can be seen that copper, as well as silver and cobalt, were produced from the Silver Glen workings at Alva. It appears that mining around Alva was restricted by awkward terrain and lack of capital, as well as by the small size of the deposits.

All the known mineralisation in the volcanic rocks of the Ochil Hills is along fault planes and fracture zones. The three main trends have all been mineralised to some extent but are characterised by different mineral associations (Francis *et al*., 1970). The NNW–SSE trend is the commonest, with a baryte–copper association, with iron (pyrite) and lead occurring in small quantities and calcite and quartz as less common gangue minerals. The NE–SW trend has a calcite–iron oxide association. Silver with minor cobalt, copper and lead occur, and baryte and quartz are less common gangue minerals. The E–W trend, the least common and with the least well-defined strike, has a calcite–pyrite association. Silver and copper, with subordinate lead, arsenic and cobalt also occur, with quartz and minor baryte as gangue minerals. The West

Ochil Fault also follows this trend, but there is no mineralisation visible or recorded at the few localities where it is exposed. It has been suggested that the NE–SW- and E–W-trending faults (i.e. the calcite–iron associations) were mineralised during the PermoCarboniferous and the NW–SE trend was mineralised in Palaeogene (Tertiary) times. K–Ar ages on illite-rich concentrates from the mineralised rocks of the Alva area are latest Carboniferous to Early Permian (260–300 Ma; Ineson & Mitchell, 1974).

Several metallic elements are appreciably enriched in the volcanic rocks when compared against crustal abundance values for basaltic rocks, e.g. As, Rb, Zr, Mo, Ag, Sb, Pb, Th and U. On this basis, it can be inferred that the rocks of the Ochil Volcanic Formation represent suitable source-rocks for most of the metals now found in the vein structures. The exceptions are Cu and Co, for which the values are only about one half of those of the average basalt, and possibly also Ba which is present at only normal levels in the lavas and fragmental volcanic rocks.

Leave the car park [NS 8985 9750] and head westwards up the nearby forest track on the north side of the road. About 400 m along this slowly rising track, take the narrow path leading slightly southwards until it crosses the Silver Burn. Apart from a thin cover of hillwash and talus in places, the area is largely drift-free, but natural exposure has been modified by spoil from the old mine workings and opencast trenches dug along mineralised structures

Locality 6.1 [NS 8920 9760] Path at Silver Burn: quartz-dolerite sill, volcanic rocks

In this area, a component of the Midland Valley Sill-complex has been intruded along the line of the West Ochil Fault. This intrusion has a pod-shaped outcrop which is about 80 m wide in Silver Glen, and the agglomerate that it cuts is bleached, brecciated and contains a little disseminated pyrite near the contact. The dolerite is exposed in crags just below the path. To the north of the intrusion the succession comprises alternations of thin andesitic lavas and coarse-grained reddish-brown volcaniclastic rocks, which are overlain by a thick sequence of andesitic lava flows. Continue straight on at the top of the path, where the ground flattens out, onto a footbridge over the burn (ignore a path on the right that goes up into the woods).

Locality 6.2 [NS 8917 9762] Adits A and B, shaft C

The main mineralisation occurs between the ENE–WSW fault (K in (Figure 6.1)) and the NW–SE fault H. No mineralisation is seen along fault K, but the parallel fault F, some 30 m to the north, is one of the most important mineralised structures in the Alva district.

Adit A [NS 8932 9764] into the east bank of Silver Burn and adit B [NS 8295 9763] driven into the west bank follow fault F, which has been offset by N–S fault J. A narrow trench, which has been cut on the east bank due east of B, is believed to have been a barren trial dug in an attempt to follow F on the east side of the stream. The mineralisation is in a breccia *c*.0.6 m wide and comprises calcite, quartz, pyrite, chalcopyrite, malachite, arsenopyrite, argentite (Ag_2S), galena, erythrite ($Co_3(AsO_4)28(H_2O)$), ferruginous gouge and botryoids of hydrocarbon. Adit A (Plate 6.2), on the offset continuation of F, is the entrance to a chamber 6 m by 4 m, which was the alleged site of the rich silver lode known as the ‘Silver Chamber' (but see Moreton (1996) for the probable location of this site, i.e. Locality 6.4). The mineralised fault and an associated altered thin basic dyke can be seen in the chamber where they are offset by another roughly N–S fault (I) which has also been mineralised. Mineralised zone I is more variable in thickness (maximum 0.4 m) and carries baryte, quartz, chalcopyrite and malachite. Entrance to the chamber is now barred by a grill, so the following paragraph is included only for information.

Levels have been driven along the extensions of these structures from the chamber. From the SE corner a level has been driven for about 30 m trending 164°, where the structure dips 78°W and a drivage has been made on the continuation driven from the NE corner of the chamber for *c*.5 m trending 350°. From the eastern side of the chamber a level has been driven for *c*.10 m along the extension of the main structure (F) trending 064° and dipping 78°S. An irregular, subvertical structure is intersected in the NE corner of the chamber and also in the shaft that has been sunk in the SW corner of the chamber. This mineralised breccia appears to be developed at the intersection of the two main structures and has a pipe-like form with a variable diameter depending on the host rock. Where seen, the pipe is 1 m

wide and contains baryte, pyrite, chalcopyrite, malachite, ferruginous gouge and botryoids of hydrocarbon. Calcite, quartz, arsenopyrite, argentite, galena and erythrite have also been recorded previously. The shaft in the chamber is about 2.5 m square and descends for about 12 m. A small trial has been driven to the south about 2 m below the floor of the chamber, and another level has been driven to the east at about 10 m down. A 20 m winze (*an opening in an underground mine that is sunk downwards*) led down from this intermediate level to a lower level, which in turn had access to the surface by an unlocated adit in Silver Glen some 60 m to the south of the northern margin of the quartz-dolerite (note there are two fenced-off adits to the south of the path in the area of dolerite outcrop). There is also access to the shaft from a winze in the NE corner of the chamber and above this is another shaft from ground level into the chamber. Channel samples were collected from the mineralised structures in the Silver Chamber and analysed (Hall *et al*., 1982, appendix II, table IV). The east and south drivages gave anomalously high copper and silver and higher than normal cobalt values; the north drivage gave anomalously high copper, but neither adit A, the trial from the shaft, nor the intersection gave any high values. Adit B was driven west along structure F, to join shaft C [NS 8917 9762], which is also connected to adit M. Surface trenching along the crop of F has been carried out between B and C and at intervals for some 50 m west of C.

Although native dendritic silver is the chief primary ore, proustite (Ag_3AsS_3 silver arsenic sulphide), and an un-named silver bismuth selenide are rare additional ones. Clinosafflorite ((Co, Fe, Ni)As_2 cobalt– iron–nickel arsenide) is the only primary nickel ore identified. Other arsenides recorded are rammelsbergite ($NiAs_2$), nickeline (NiAs) and maucherite ($Ni_{11}As_3$). Secondary minerals include pink erythrite (Co_3 $(AsO_4)_2 \cdot 8(H_2O)$ hydrated cobalt arsenate), green to bluish tyrolite ($CaCu_5(AsO_4)2(CO_3)(OH)_4 \cdot 6(H_2O)$ hydrous carbonated arsenate of calcium and copper), green annabergite ($Ni_3(AsO_4)_2 \cdot 8(H_2O)$ a nickel arsenate) and green conichalcite ($CaCu(AsO_4)(OH)$ hydrated copper calcium arsenate).

Locality 6.3 [NS 8921 9766] Adit D

About 20 m upstream from adit A is adit D, which is driven on a mineralised vein trending 020°. At 6.5 m in from the entrance, a small chamber 2.5 m square has been developed with a water-filled shaft at least 20 m deep in the NW corner. Thin cross-cutting veins, trending 300°, seen near the shaft are probably related to the NW–SE fault (H) seen at the surface. From the NE corner of the chamber a level has been cut in mineralised breccia on an average trend of 065° for about 50 m. The mineralisation is calcite, quartz, ferruginous gouge, pyrite, chalcopyrite, argentite and botryoids of hydrocarbon. Trenching at the surface probably followed the crop of the vein and is crossed by a narrow trench running NW–SE parallel to H. Channel samples (Hall *et al*., 1982) taken at intervals along this drivage gave high copper values at 10 m in from the entrance at the approximate intersection with the cross-cutting structure H.

Locality 6.4 [NS 8917 9770] Adit and shafts E: Silver Mine

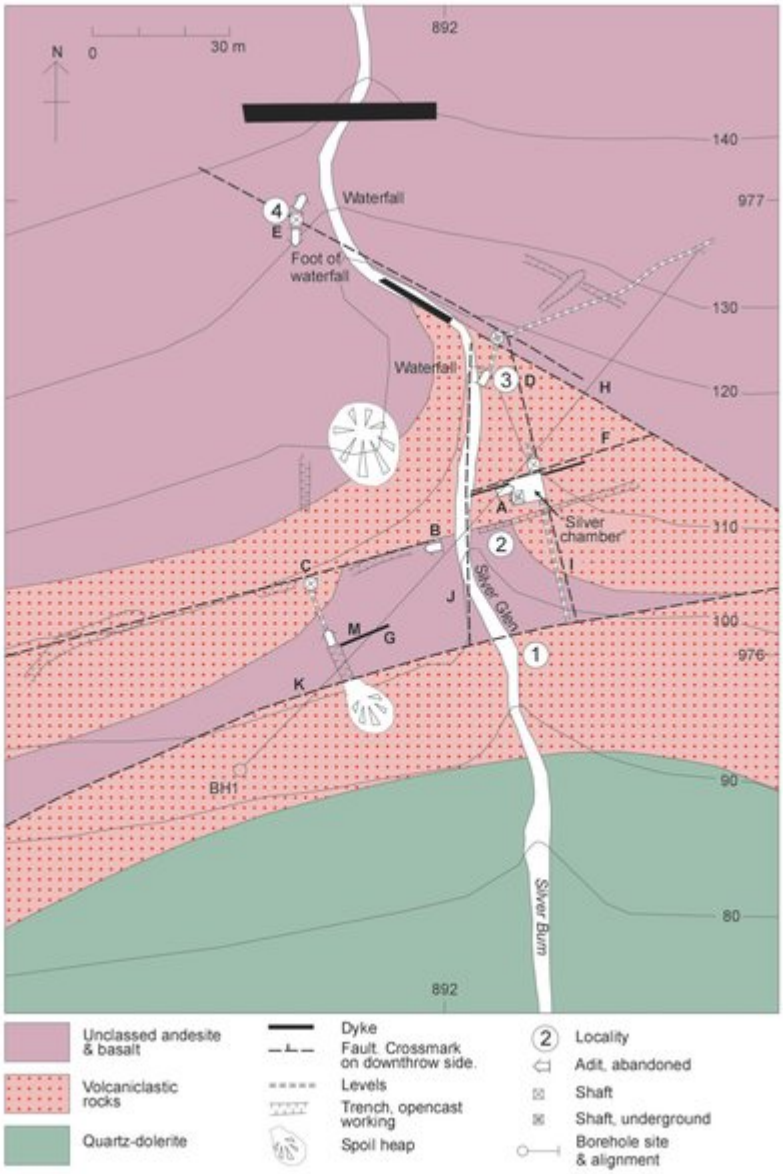
Sixty metres NW of adit D another working, E, is developed on the NW–SE fault (H) and in a similar tectonic setting to the workings at D. It comprises an opencut 10 m deep, or possibly a collapsed shaft, an adit driven south on a 170° trend, and adits driven to the north trending 030° at three different levels. The lowest of the north drivages is accessible and shows the vein splitting into two sections 5 m from the entrance. The mineralisation is dominantly baryte with some calcite and traces of copper. The drivage to the south is blocked near the entrance, but some baryte veins are seen on its projection in the drivage between adit B and shaft C. Some surface trenching to the north of shaft C follows a similar trend. Channel samples (Hall *et al*., 1982) collected from both branches of the drivage to the north show high copper values. The sample collected from the drivage to the south shows high cobalt and nickel values and moderately high copper values. Working E is now believed to be the Silver Mine (Moreton, 1996).

The order of mineral deposition was silver followed by cobalt, nickel, arsenic and dolomite, and finally baryte and calcite. The initial mineralising fluids must have been sulphur deficient because there are no silver sulphides or sulphosalts. The sulphate in the baryte was sourced from groundwater rather than seawater so mineralisation is land based. The source of the hydrocarbons is the adjacent Carboniferous rocks. The intrusion of the latest-Carboniferous quartz-dolerite may have provided the heat source to drive the mobilisation and emplacement of the minerals. At Silver Glen the main mineralisation is associated with very altered minor intrusions which appear to be integral parts of the complex hydrothermal veins. The presence of quartz-dolerite here may be significant but, since silver was also mined at Airthrey

[NS 815 972] at a considerable distance from any known quartz-dolerite, its role here is more likely to be secondary remobilisation than genetic.

The suggested principal controls of polymetallic mineralisation in the western Ochils may be summarised from Hall *et al*. (1982) as: eruption of Early Devonian volcanic rocks containing traces of copper, barium, silver and cobalt and therefore favourable as source rocks; emplacement of calcite–pyrite mineralisation with associated silver and cobalt along E–W structures, probably part of the Ochil Fault-system; development of penecontemporary N–S structures with concentration of mineralisation at the intersections of these and the E–W structures; later copper–barium mineralisation associated with NW–SE and NE–SW faulting of Late Palaeozoic or younger age.

References



(Figure 6.1) Geological map of the Silver Glen, Alva, showing localities for Excursion 6. Adapted from Hall, Gallagher et al. (1982, fig. 4a).

(Plate 6.1) View north across the Devon valley towards the West Ochil Fault-scarp. Alva Glen (left) and Silver Glen (right) lie on either side of the pointed hill (The Nebit).

(Plate 6.2) Locality 6.2. Adit to the 'Silver Chamber' in east bank of Silver Burn.