The distribution of gold and silver in the crystalline rocks of the Malvern Hills.

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IN re-examining the crystalline rocks of the Malvern Hills, the senior author has had occasion to apply quantitative spectroscopic data for the rarer constituents of hornblendes and micas. The recognition of silver in the spectrograms of biotite led to tentative fire-assays of granitic rocks in bulk—a procedure which revealed the presence also of gold.

The assay results for this preliminary suite of granitic types are given below; values less than 5 grains per ton are returned as 'traces':

Rock-type, and reference to 'List of localities', p. 263.	Number of samples assayed.	Gold grains per ton.	Silver dwt. per ton.[1]
Granites: grey, pink, and reddish:			
Loc. *a*, *b*, *c*, *d*, *e*, and *j*	4 ...	trace ...	Av. 0·5
	5 ...	,, ...	,, 1·3
	2 ...	,, ...	,, 3·0
Granites: strongly reddened:			
Loc. *b*	2 ...	,, ...	,, 9·4
,, *d*	1 ...	,, ...	,, 33·6
,, *b*	1 ...	72 ...	,, 42·4
Pegmatites:			
Loc. *d*: grey; muscovite-rich ...	1 ...	trace ...	,, 0·4
,, *b*: red; quartz-felspar ...	3 ...	,, ...	,, 8·0

The higher values appear to be related to the reddening of the felspars, which is a widespread 'late' pneumatolytic effect; it is conspicuous in the major granite masses and related pegmatites, but somewhat local and 'arterial' in its distribution over rocks of pre-

[1] 1 pennyweight (24 grains) per ton (2240 lb.) = 1530 milligrams per metric ton (1000 kg.).

granite age. Among the igneous rocks of post-granite age, the intrusive granophyric quartz-diabase ('Ivy Scar' type) shows only feeble reddening; the newer dolerites are unaffected.

As the contaminated character of the granite-granodiorite kindred here is one of the more obvious features, the possibility that their content of gold and silver might have been derived in the first instance from external sources rendered assay work on other rock-types obligatory.

The assemblage of Malvernian types sampled for this purpose comprises the following:

I. *Crystalline schists:*

(*a*) Sillimanite-bearing and garnetiferous quartz-, quartz-chlorite-, quartz-chlorite-mica-schists, with varieties containing felspars, hornblende, zoisite, epidote, apatite, sphene, ilmenite, magnetite, haematite flakes, and calcite in varying proportions.

(*b*) Biotite-rich schists of pelitic type, grading into varieties described above.

(*c*) Schisted sandstones. Stout ribs in granite are highly modified along their margins.

(*d*) Amphibolites, hornblende-schists, and hornblende paragneisses, grading into biotite-rich varieties, with varying amounts of quartz, felspar, garnet, epidote, &c.

(*e*) Phyllites, usually quartz-banded.

II. *The pyroxenite-hornblendite kindred* (with felspathic and micaceous variants) and related appinites, many of which are demonstrably of 'mixed' origin. In the main they are older than the red granite. With these may be grouped some intrusive masses of 'appinitic' diorite, syenite, monzonite, &c., and a widespread 'gabbro-diorite' comparable to the rock quarried at Hollybush.

III. *Granites, granodiorites, &c.* The true granites belong to more than one time-stage in the Malvernian sequence. The older types are represented by thin intercalates of grey granite, &c., and broader bands of granite, aplite, felsite, and granitoid paragneiss in the banded crystalline schists. The newer granites are more massive, and typically pink or red; they also contribute intercalates (locally tourmaliniferous) to the injection-complex.

The red granite-pegmatites belong to the latest phase of granite-intrusion.

The modification of granites, granodiorites, &c., to 'unakite' is attributable to migratory solutions carrying the constituents of epidote, with haematite, plagioclase, quartz, and sphene.

IV. *Post-granite intrusions* include the following:

A granophyric quartz-diabase type, most frequently encountered north of the Wyche. The type locality is Ivy Scar.

Dolerites.

At least one occurrence of appinite, which is intrusive into the granophyric quartz-diabase.

V. *Epidosites*,[1] *epidote-quartz-, and epidote-quartz-plagioclase vein-rock.* These are widely distributed, and traverse all types, including those described in IV.

The supplementary assay-results are given in the following sections:

Rock-type and locality.	Number of samples assayed.	Gold grains per ton.	Silver dwt. per ton. Average.
Crystalline schists:			
Banded quartz-chlorite-sericite-phyllite. Loc. *k* ...	1 ...	trace ...	0·4
Quartz-chlorite-sillimanite-garnet-mica-schist. Loc. *f* ...	3 ...	,, ...	0·4
Quartz-chlorite-mica-schist. Loc. *a* ...	1 ...	,, ...	0·4
Banded schist-and-gneiss complex:			
Granitoid: grey, patchily reddened. Loc. *a* ...	2 ...	,, ...	0·4
,, *f* ...	5 ...	,, ...	0·5
,, *b* ...	2 ...	,, ...	1·1
,, *m* ...	2 ...	,, ...	2·4
,, ,, ...	2 ...	,, ...	2·5
,, *g* ...	1 ...	9 ...	5·2
,, ,, ...	1 ...	8 ...	21·5
Granitized schisted sandstones, in contact with red granite. Loc. *b* ...	2 ...	trace ...	2·0
,, ,, ...	1 ...	,, ...	6·8
,, *e* ...	1 ...	,, ...	10·4
Quartz and epidote:			
Quartz aggregate, from red granite and red granite-pegmatite. Loc. *a, b, c, d*	2 ...	trace ...	0·5
Epidosite. ,, *j*[2] ...	1 ...	nil ...	trace
,, ,, *g* ...	1 ...	,, ...	1·2

[1] A. F. Smethurst, Anomalies in the analytical determination of water in epidote. Min. Mag., 1935, vol. 24, pp. 173–179.

[2] A. F. Smethurst, loc. cit., p. 176, analysis specimen A.

Rock-type and locality.		Number of samples assayed.	Gold grains per ton.	Silver dwt. per ton.
Amphibolites and hornblende-schists:				Average.
Quartz-banded.	Loc. *k*	6	trace	1·2
Compact, uniform.	,, ,,	6	,,	1·5
Migmatitic: highly modified by silica-rich solutions from red granite: reddish and purplish migmatites.				
	Loc. *c*	1	,,	4·6
	,, ,,	1	29	0·7
Derivative epidiorites.	,, *b*	2	trace	1·4
	,, *h*	1	,,	2·8
Derivative 'appinitic' diorites, 'Hollybush' type.	Loc. *l*	2	nil	trace
	,, *b*	2	,,	0·7
Pyroxenite-hornblendite kindred:				
Biotitite: pegmatitic.	Loc. *c*	3	,,	0·4
,, with grey felspars.				
	Loc. *c*	2	,,	trace
Hornblendite.	,, ,,	1	,,	0·7
,, with grey felspars.				
	Loc. *c*	1	trace	1·2
Biotite-hornblende-pyroxenite.				
	Loc. *c*	2	nil	1·7
,, hybridized to coarse red appinitic pegmatite.	Loc. *c*	1	trace	8·3
Derivative granodiorite.	,, ,,	1	,,	13·2
Biotite-hornblendite, with grey felspars.	Loc. *c*	4	,,	0·4
Appinitic derivatives.	Loc. *c*	3	nil	trace
Quartz-diabase (*'Ivy Scar' type*):				
	Loc. *i*	1	trace	1·4
	,, *e*	3	,,	1·5
Newer dolerites:	,, *b*	4	,,	1·6
Pyrite aggregate from schists:				
	Loc. *c*	1	5	1·1
Chalcosine veinlet:	,, *j*	1	trace	39·6
Fault-gouges:	,, *c, d*	5	tr.–4	0·4

List of Localities.

a. Hay Slad quarries, ½-mile nearly due south of Worcester Beacon.
b. ,, ,, ,, ½-mile due south of Worcester Beacon.
c. Tollgate quarries, west side of main road, ⅛-mile north of Wyche.
d. ,, ,, ,, ,, ,, about ¼-mile north of Wyche.
e. Worcester Beacon.
f. Enclosure immediately north of the 'Gold Mine', ¼-mile north of Wyche.
g. Crag (east side of hill-track), ¼-mile SSW. of Worcester Beacon.
h. ,, ¼-mile ESE. of Worcester Beacon.

i. Ivy Scar crags.
j. North Malvern ('Pyx') quarries.
k. Gullet quarry.
l. Hollybush quarry.
m. Hill-side, about 400 yards due east of Worcester Beacon.

The results are consistent among themselves, and their correlation leads to the following conclusions:

1. In the more basic igneous rocks, comprising pyroxenites, hornblendites, appinitic diorites, &c., intrusive diorites and dolerites, the prevailing gold and silver values are low, of the order 1 grain of gold and 1 dwt. of silver per ton.

2. The same low values prevail in
   (*a*) the grey granites and gneisses,
   (*b*) the granitoid crystalline schists and paragneisses,
   (*c*) amphibolites, hornblende-schists, and their biotitic varieties,
   (*d*) hornblende, basic micas, muscovite, epidote, quartz, and basic plagioclase.

3. The higher values are associated with the red granites and red-granite pegmatites, and with various types of 'mixed' rocks to which the red granites have been contributory. They are probably related to disseminations of haematite attributable to pneumatolytic processes which distinguish the latest phase of granite intrusion.

For the sampling schedule, and the interpretation of the assay results, the senior author alone is responsible. The actual sampling and the whole of the assay work were done by Mr. Dowie.

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