powerful W.N.W. channels of mineralization in the district, with a yield so far of 460,000 tons of fluor spar and 48,000 tons of galena. The collar of the boring is also 500 ft. from the hanging wall of the E.N.E. Boltsburn Vein, a weak but very persistent fracture, which has yielded 143,000 tons of galena, mainly from associated replacements. Both veins dip towards the boring, which was sited so as to pass through them at depth. Below the Great Limestone, the base of which is taken as the Viséan-Namurian boundary in northern England, a normal Middle Limestone Group succession was encountered. Two quartz-dolerite sills were proved in these beds; the Little Whin Sill, 6 ft. thick, is intruded into the Three Yard Limestone, and the Great Whin Sill, 200 ft. thick, lies beneath the Jew Limestone. The base of the Middle Limestone Group remains to be defined exactly when the faunal study of the cores has been carried out, but the expected change from dark blue-grey limestone to pale grey limestone shows the approximate position of this boundary. The Lower Limestone Group is represented by an alternation of light grey limestones, shales and sandstones; no massive Melmerby Scar Limestone such as is present below Cross Fell is developed; but the typical 'pseudo-breccia' lithology characteristic of this limestone is present in some of the bands. Beneath these light-coloured limestones, black shale with very thin quartz- and feldspar-bearing conglomerate beds rest directly on weathered granite which in a few feet gives place to fresh, well-foliated microcline-quartz-muscovite-oligoclase rock. The foliation is nearly horizontal, and aplite and pegmatite bands occur at various angles.

So far, ten intersections of metalliferous mineralization have been made. Of eight in the Carboniferous, three are horizontal replacements in limestone and one of these is 16 ft. thick, rich in green fluorite and sphalerite. Two typical Pennine Zone I veins, carrying pyrrhotite, fluorite, quartz, have been intersected within the granite at 1,349-1,363 ft. and at 1,585-1,656 ft., the latter being accompanied by extreme alteration of the granite.

Two definite conclusions may be drawn at this stage: (1) the granite so far proved is of pre-Carboniferous age; (2) the mineral veins were fed from some source beneath that part of the granite so far drilled. To these may be added the suggestion that the buried pre-Carboniferous cupolas served to localize the upward flow of mineralizing fluids into the Carboniferous rocks.

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Isotopic Ages of the Weardale Granite

AGE determinations have been carried out on muscovite from the Weardale Granite¹ by both the rubidium-strontium and potassium-argon methods. One specimen from a depth of 1,396 ft. in the borehole was measured by both methods, while another from

1,314 ft. was measured by the potassium-argon method only.

Isotopic dilution techniques were employed for the determination of rubidium, strontium and argon. A flame photometric method was employed to determine potassium. The results for the rubidium-strontium method are given in Table 1, and those for the potassium-argon method in Table 2.

Table 1. RUBIDIUM-STRONTIUM DETERMINATIONS ON MUSCOVITE

Depth of sample (ft.)	Rubidium (p.p.m.)	Normal strontium (p.p.m.)	Radiogenic strontium (p.p.m.)	Age (m.yr.)
1,396	763	19.4	1.15	360 ± 12
1,396	757	19.6	1.15	365 ± 12

Decay constant of rubidium-87 = 0.1475×10^{-10} yr.⁻¹

Table 2. POTASSIUM-ARGON DETERMINATIONS ON MUSCOVITE

Depth of sample (ft.)	K ₂ O (per cent)*	Weight fused (gm.)	Radiogenic argon (p.p.m.)	Atmospheric argon (per cent)	Age (m.yr.)
1,396	10.01	2.034	0.240	17.4	370 ± 10
1,314	10.26	3.291	0.239	24	356 ± 12

Decay constants of potassium-40: $\lambda_K = 0.584 \times 10^{-10}$ yr.⁻¹

$\lambda_B = 4.72 \times 10^{-10}$ yr.⁻¹

Isotopic abundance of potassium-40 = 0.0119 atom per cent

* Potassium analyses by Dr. N. J. Snelling.

All the results agree within the limits of error. Agreement between the two methods makes it highly probable that the weighted mean of the four figures is close to the true age of emplacement of the granite.

The following points may be noted: (i) The weighted mean of 362 ± 6 million years corresponds to a Middle or Late Devonian age of emplacement, according to the latest time-scales^{2,3}. The isotopic results therefore agree with the borehole evidence for the pre-Carboniferous age of the granite. (ii) The age of the Northern Pennine mineralization from the field evidence⁴ is undoubtedly post-Carboniferous and probably pre-Tertiary. From lead isotope measurements by Moorbath⁵ the mean model age of Northern Pennine galenas is 280 ± 30 million years, indicating that the mineralization is in fact of Hercynian age. Thus, from the lead isotope data and the absolute ages, as well as from the observations reported in the preceding communication, the northern Pennine mineralization is not connected with the emplacement of the Weardale granite. (iii) The weighted mean of 362 ± 6 million years for the Weardale granite is significantly younger than the dates for the Shap granite given by Kulp *et al.*⁶. These authors obtained 391 ± 7 million years by the potassium-argon method and 381 ± 7 million years by the rubidium-strontium method. Unpublished rubidium-strontium results obtained at Oxford on the Skiddaw granite suggest that the latter may be contemporaneous with the Weardale granite.

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