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EXPLANATION OF PLATE XIII.

Alkali metal spectra of the trilobite *Deiphon* (A) and its enclosing matrix (B) showing the relative intensities of the K, Rb and Cs lines.

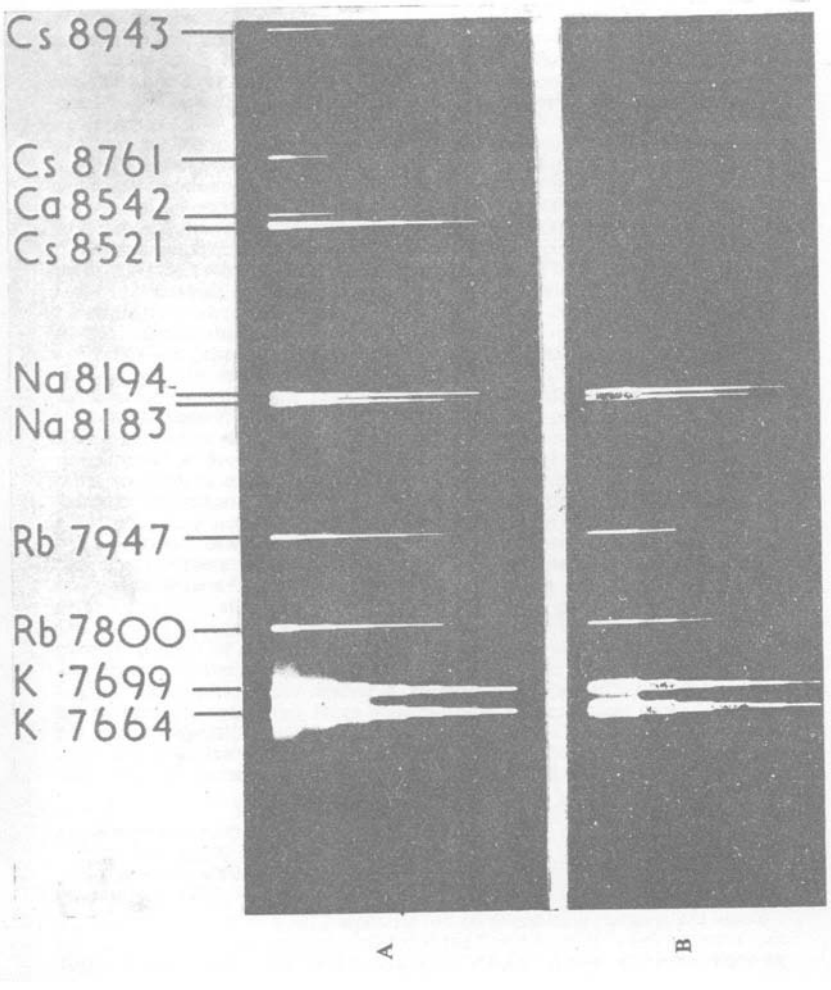
CORRESPONDENCE

THE ORIGIN OF GARNETS IN THE BORROWDALE VOLCANIC SERIES

SIR,—Dr. Firman's letter is to be welcomed as a justified comment on the writer's postulation of the " Borrowdale " garnet genesis which, though perhaps not obviously, also was submitted (*Geol. Mag.*, 1954, pp. 121–139) " with some trepidation ". In the light of Dr. Firman's arguments, the writer feels the need to discuss the problem at greater length.

It is true that garnets are rare " in lavas of any age, composition, or history "; the writer is prepared to admit that the existence of special environmental conditions were perhaps necessary for the crystallization of the garnets (see further below).

Almandine garnets have not been synthesized at atmospheric or relatively low pressures, but they have recently been synthesized at moderately high pressures. Firman's contention that there is a lack of experimental evidence



Alkali metal spectra of A: *Deiphon*. B: matrix surrounding *Deiphon*

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in support of the likelihood of almandine crystallizing from an andesitic magma is not supported by H. S. Yoder's recent work (*Amer. Min.*, xl, 1955, p. 342) on the almandine garnet stability curve which, according to Yoder, accounts for the occurrence of almandine in metamorphic rocks *as well as in some igneous rocks*. There is little doubt that the garnets (of similar composition to those in the Borrowdale volcanics) contained in, for example, the Dartmoor Granite are magmatic (see A. Brammall and H. F. Harwood, *Miner. Mag.*, xx, 1923, pp. 39–52), and pressures operating on the granite at the time of garnet crystallization are not likely to have been very much higher than those affecting the Borrowdale andesitic magma at depth.

Dr. Firman's statement that plagioclase coronas round many of the Lake District garnets are illustrative of xenocrystal garnets in disequilibrium with the magmatic liquid is not consistent with his contention that the garnets as xenocrysts free to react with the liquid might be expected to vary in composition sympathetically with the composition of the containing rock.

The closest comparison to the " Borrowdale " garnets and their environment is, as far as the writer is aware, those contained in dacitic and rhyodacitic lavas in Victoria, Australia, discussed in a number of papers by Dr. A. B. Edwards and other workers. Edwards (*Proc. Roy. Soc. Victoria*, xlix, 1936, p. 40) admits the possibility that the Victorian garnetiferous rocks are syntectics—in other words, that they have been contaminated—and the same view is held by other Australian investigators. The presence of garnets, already mentioned, in the Dartmoor Granite is attributed by Brammall and Bracewell (*Nature*, cxxxi, 1933, p. 250) to contamination by the country rock. These examples, and also several others, indicate that a higher relative proportion of alumina than can be attained by " internal " magmatic differentiation is apparently necessary for the crystallization of almandine garnets. In the Lake District, the Skiddaw Slates, underlying the Borrowdale volcanics, are a not impossible source of aluminous material.

The writer considers it quite probable that assimilation of aluminous sediment (or metamorphosed sediment) has facilitated the crystallization of the " Borrowdale " garnets. Such an explanation would account for the rather random and patchy distribution of the garnets emphasized by Dr. Firman, though it would still be compatible with the restriction of the garnets to lavas of a limited compositional range (maintained by the writer). The absence in the lavas of definite and recognizable xenocrysts or xenoliths from metamorphic rocks does not support Dr. Firman's contention that the garnets are xenocrysts from metamorphic garnetiferous rocks at depth; nor is the suggestion that welded tuffs in the Lake District are a significant host and associate of the garnetiferous rocks substantiated by the non-occurrence of garnets in most welded tuffs recorded elsewhere.

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9th October, 1956.

THE AMMONITE GENERA *ARNIOCERAS* AND *CORONICERAS* HYATT

Sir,—In his account of the Liassic ammonites of the Stowell Park boring, published summer, 1956, Dr. Spath makes incorrect statements as to the type species of the above genera. In view of Dr. Spath's high authority on Liassic ammonites it is desirable to point this out in case other authors are misled into erroneous concepts of the genera.

Arnioceras Hyatt, 1867.—Dr. Spath (1956, p. 151) states that the type species " remains *A. ceratitoides* (Quenstedt) ". Apart from any question as to the identity of this species, the type species of the genus *Arnioceras*