

BORON IN PEGMATITE MINERALS

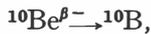
By

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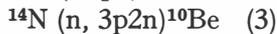
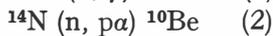
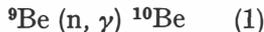
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In a paper on the distribution of boron in pegmatite minerals, OFTEDAL (1964) observed that boron is relatively enriched in rare earth pegmatite minerals, and the enrichment is largely restricted to metamict specimens (OFTEDAL pp. 223–224). He also noted an uneven distribution in these minerals indicating a connection between the alteration process and the boron enrichment. Most of these minerals, with the exception of gadolinite, contain no atoms for which boron is likely to substitute, and OFTEDAL suggested a secondary (post metamictization) introduction of boron. The mobility of boron in the crust is high, and the preferential adsorption of boron may be explained by unsatisfied electrostatic charges in the ‘amorphous’ metamict minerals. The purpose of this note is to bring to attention the possibility of a radiogenic formation of this excess boron.

^{10}B is the stable product of the negative β -decay of ^{10}Be ,



with a half life of 2.5×10^6 yrs. ^{10}Be may form in the reactions:



The radiogenic formation of ^{10}Be from nitrogen takes place in the atmosphere. WHITE and YAGODA (1950) gave data on $^{14}\text{N}/^{15}\text{N}$ ratios which suggested that this reaction takes place in pitchblende and uraninite. This is not confirmed by later work (RANKAMA 1963). Their data would suggest an appreciable generation of ^{10}Be , and consequently of ^{10}B , in Precambrian uraninites. OFTEDAL (1964) claims a

detection limit of 0.01% B_2O_3 (about 30 ppm B) but does not detect boron in uraninites examined by him. This would suggest: (a) the isotope determinations of WHITE and YAGODA are incorrect; (b) the differences in the isotope ratios are caused by other processes; (c) the Be and/or B endproducts, which do not occupy structural sites, are removed from the minerals. This could be the source of the boron introduced and adsorbed to the metamict minerals.

U and Th produce neutrons by spontaneous fission, but at a very slow rate. However, the reaction ${}^9\text{Be}(\alpha, n){}^{12}\text{C}$ will give a fair yield of neutrons in U and Th minerals containing Be. OFTEDAL (1939) determined Be not exceeding 100 ppm in several metamict pegmatite minerals, and it was then suggested that these minerals may constitute a natural neutron source. It is very significant that OFTEDAL in his recent paper finds significant concentrations of B in gadolinite ($\text{Be}_2\text{FeY}_2\text{O}_2(\text{SiO}_4)_2$); and especially that *perfectly crystalline gadolinite is considerably poorer in boron than the majority of the metamict gadolinite specimens*. Metamictization of minerals is not well understood (see below) but is certainly associated with the presence of radioactive elements in the lattices. OFTEDAL does not comment on the U and Th concentrations in the gadolinites but it would be surprising if these were not highest in the metamict specimens. OFTEDAL's observations on B in metamict pegmatite minerals may indicate a radiogenic origin which is accentuated in minerals containing Be as well as U and Th. The validity of this suggestion can be examined by:

- (1) comparative analyses of Be in metamict and nonmetamict specimens of minerals,
- (2) radiometric determinations of ${}^{10}\text{Be}$ in metamict minerals,
- (3) isotope determination of the boron in metamict minerals,
- (4) determination of ${}^7\text{Li}/{}^6\text{Li}$ in metamict minerals (${}^7\text{Li}$ is produced by ${}^{10}\text{B}(n, \alpha) {}^7\text{Li}$),
- (5) measuring the neutron flux in metamict minerals.

It is tempting to consider the metamictization of minerals. This process is not well understood but is restricted to minerals containing U and Th without being directly related to the concentrations of these elements. Thorianite (ThO_2) and uraninite (UO_2) are generally crystalline. The stability of the structure, the total α -activity of the mineral, and the age of the mineral, are all factors affecting the

degree of metamictization. Minerals that are strongly ionic compounds do not become metamict (see RANKAMA 1963, for a most recent discussion). The α -particle bombardment through natural radioactive decay is of low energy (about 5 m.e.v.) and the recoil energy of the ^{12}C nucleus (from ^9Be (α , n)) is of a similar magnitude. This will be sufficient to break the chemical bonds holding ^{12}C in the lattice, and its higher mass enables it to transfer more of its energy per collision. Maybe the metamict state depends on the presence of Be, as well as U and Th, in the lattice? If this is the case the relation between the alteration process and the boron enrichment in metamict minerals (OFTEDAL 1964, p. 223) is easily understood.

Acknowledgement

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REFERENCES

- OFTEDAL, I. 1939. Beryllium in radioactive minerals. Norsk geol. tidsskr. Bd. 19, pp. 341-342.
- 1964. On the occurrence and distribution of boron in pegmatite. Norsk geol. tidsskr. Bd. 44, pp. 217-225.
- RANKAMA, K. 1963. Progress in isotope geology. Interscience publ. John Wiley and Sons, 705 pp.
- WHITE, W. C. and YAGODA, H. 1950. Abundance of N^{15} in the nitrogen occluded in radioactive minerals. Science 111, p. 307.

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