

Arfvedsonite in basalt dykes, Buchans, Newfoundland

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Abstract

Arfvedsonite, an uncommon sodic amphibole, occurs in basalt dykes at Buchans, Newfoundland. Stability and textural relations suggest that the mineral grew during subsolidus cooling of basalt within the submarine geothermal system which persisted during contemporaneous massive sulfide ore formation. It is only sporadically preserved, readily altering to chlorite during prehnite-pumpellyite facies metamorphism or associated hydrothermal alteration. Sodic amphiboles may occur more widely in similar parageneses than has previously been recognized.

Arfvedsonite, the uncommon sodic amphibole, has been recognized in prehnite-pumpellyite facies metabasalts from the Buchans area, Central Newfoundland. The mineral occurs sporadically within submarine vesicular basalt dykes cutting vesicular basaltic andesite breccias of the Lower Silurian Red Indian Formation ("Footwall Andesite") in drillcore 800 feet beneath the Buchans polymetallic massive sulphide deposit. The geology of the area and of these deposits is described by Thurlow *et al.* (1975).

The amphibole in this occurrence is strongly pleochroic from straw yellow to deep blue-green, with length-slow orientation, strong dispersion, and a maximum extinction angle of 22°. Absorption colors and extinction are variable within single grains, probably reflecting the compositional heterogeneity revealed by electron microprobe analyses. The average of four partial electron probe analyses gave the following composition (weight percent): SiO₂ 49.8, TiO₂ 2.14, Al₂O₃ 0.78, FeO 33.9, MnO 0.70, MgO 1.65, CaO 2.09, Na₂O 6.86, K₂O 0.90; semi-quantitative analysis showed the order of 0.05% Cl but no detectable F. The structural formula estimated by the procedure of Finger (1972), based on 23 oxygens, is Si 7.74, Al^{IV} 0.14, Ti 0.25, Fe³⁺ 0.93, Fe²⁺ 3.48, Mn 0.09, Mg 0.38, Ca 0.35, Na (M4) 1.65, Na(A) 0.42, K(A) 0.18, OH 2.0. The amphibole was diagnosed as arfvedsonite, following the classification of Papike *et*

al. (1974) and on the basis of optical properties. The high Ti contents are similar to those reported in the literature, and entry of Ti into tetrahedral sites is suspected through low tetrahedral cation totals. Single grains are heterogenous, but no systematic pattern of zoning could be detected by scanning or point analyses; magnesium varies sympathetically with ferrous iron and to a lesser extent with calcium. Compositions vary markedly between grains.

The amphibole forms sharply bounded crystals and crystal fragments (up to 0.15 mm long), occasionally in ophitic contact with primary titanite and plagioclase. Isolated grains, often extensively corroded, occur within patches of secondary matrix or amygdular chlorite, and rarely the amphibole mantles quartz (?) or quartz-chlorite aggregates. These grains develop a distinct blue-green rim in contact with matrix chlorite and become inter-fingered with it through preferential replacement along amphibole cleavages (Fig. 1). Definitive microprobe analyses could not be obtained in this region—low analytical totals suggest hydration and partial alteration to a chlorite intergrowth. Chlorite itself is an early-phase alteration product of matrix and an amygdular phase clearly postdating the amphibole. Pervasive low-pressure (≤ 1 kbar) partial alteration of the host basalts to prehnite-pumpellyite facies will be described elsewhere (Henley and Thornley, in Swanson, in preparation), and together with extensive hydration and oxidation may have resulted from sub-sea-floor geothermal activity associated with massive

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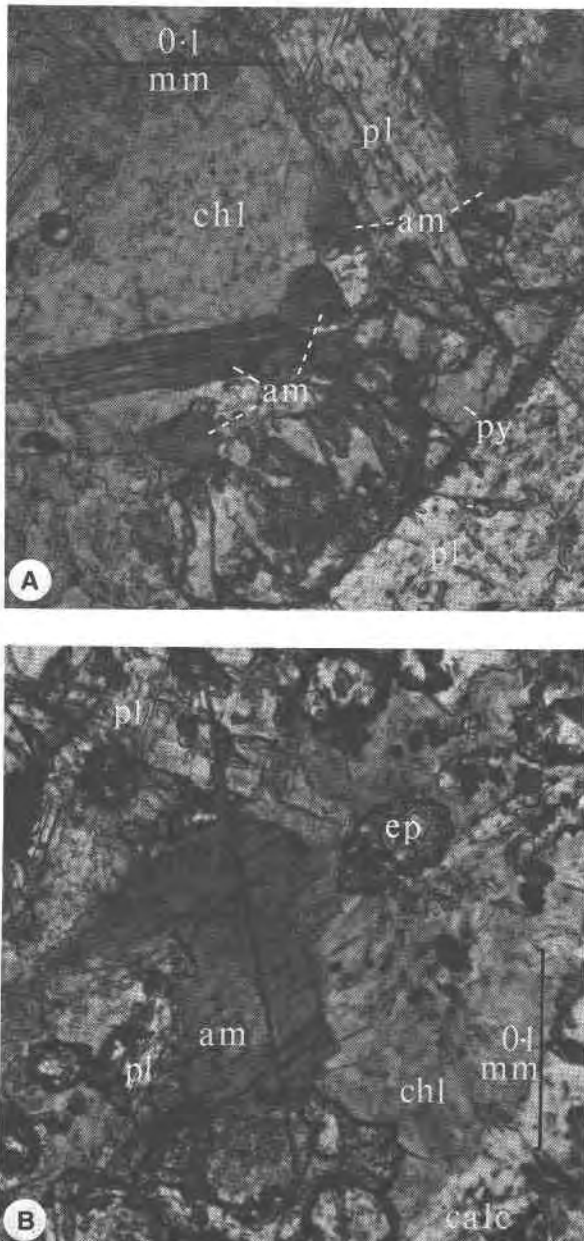


Fig. 1. (a) Arfvedsonite altering to chlorite along cleavages (sample 542-952). (b) Large arfvedsonite grain, altering to chlorite and in sharp contact with plagioclase (sample 542-816). py = pyroxene, pl = plagioclase, chl = chlorite, ep = epidote, calc = calcite.

sulfide ore formation. The basalts and overlying felsic volcanics have been ascribed an island-arc calc-alkaline affinity by Strong (in preparation), and Thurlow (personal communication, 1977) has speculated on

some petrographic affinity between the arfvedsonite-bearing dykes and local alkali gabbro and granite intrusions.

The upper stability limit of arfvedsonite is dependent upon oxygen fugacity but is of the order of 700–750°C (Ernst, 1968, p. 77–101). This precludes a liquidus paragenesis for the amphibole in these dykes but suggests that the arfvedsonite is deuteritic, nucleating and growing during submarine subsolidus cooling. This parallels the deuteritic paragenesis of similar alkalic amphiboles previously described only from alkaline granites (reviewed by Deer *et al.*, 1963). Black (1970) has documented a somewhat similar occurrence of riebeckite–arfvedsonite in glaucophane–lawsonite-bearing basalts from New Caledonia. The amphibole at Buchans is only sporadically preserved, having been readily altered to chlorite during metamorphism, so that elsewhere alkalic amphiboles may more commonly occur in this paragenesis than previously recognized. Recent studies have shown that amphiboles, generally of actinolitic affinity, are developed in some present-day geothermal systems (P. R. L. Browne, New Zealand Geological Survey, personal communication).

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References

- Black, P. M. (1970) Coexisting glaucophane and riebeckite–arfvedsonite from New Caledonia. *Am. Mineral.*, 55, 1061–1064.
- Deer, W. A., R. A. Howie and J. Zussman (1963) *Rock-Forming Minerals*, vol. 2. *Chain Silicates*. Longmans, London.
- Ernst, W. G. (1968) *Amphiboles*. Springer-Verlag, New York.
- Finger, L. W. (1972) The uncertainty in the calculated ferric iron content of a microprobe analysis. *Carnegie Inst. Wash. Year Book*, 71, 600–602.
- Papike, J. J., K. L. Cameron and K. Baldwin (1974) Amphiboles and pyroxenes: characterization of other than quadrilateral components and estimates of ferric iron from microprobe data. *Geol. Soc. Am. Abstracts with Programs*, 6, 1053–1054.
- Thurlow, J. G., E. A. Swanson and D. F. Strong (1975) Geology and litho-geochemistry of the Buchans polymetallic sulfide deposits. *Econ. Geol.*, 70, 130–144.

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