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Serendibite, to a first approximation, Ca$_2$(Mg, Fe$^{2+}$)$_2$3(Al,Fe$^{3+}$)$_4$2B$_1$5Si$_3$O$_{20}$, has been reported from about eight localities worldwide (Deer et al., 1978; Nicollet, 1988), including Johnsburg, New York, in the southern Adirondack Highlands (Larsen and Schaller, 1932; Grew et al., in press). It is a mineral of high-temperature calc-silicate skarns, mostly in the granulite-facies. In this paper we report a new occurrence from the northwest Adirondack Lowlands. This occurrence has many mineralogical and chemical features in common with the serendibite-diopside rocks in the Johnsburg deposit, although located 130 km distant.

Serendibite occurs in core from hole 1872 drilled by St. Joe Resources Company (presently
Zinc Corporation of America) near Cassidy Road, 350m south of Town Line Road, town of Russell, NY (44°31'N, 75°09' E). The drill hole penetrated calc-silicate rocks and marbles typical of the northwest Adirondack Lowlands (e.g. Bohlen et al., 1985). A summary of the core log to 40m is as follows (compositional layering intersected at high angle by the vertical core).

0–6m: Overburden.

6–8.5m: Biotite–diopside calc-silicate granulites (e.g. at 7m, plagioclase–biotite–titanite–hornblende–diopside)

8.5–30m: Diopside granulate with disseminated cm-sized books of phlogopite, alternating with amphibole–phlogopite rock at 16.8m, serendibite–diopside rock at 17.7m, and finely layered quartz-rich diopside–K-feldspar–titanite granulite at 22–25m.

30–37.5m: Dolomite–calcite marble with serpentine (after forsterite?), minor spinel and phlogopite.

37.5–40m: Diopside-rich granulite.

The serendibite-diopside rock occurs over an interval of 13–20cm (largest core fragment is 5cm long). Recovery of the core was not complete and we are not able to fully characterise the layering in this section of the core. The closest rocks to the serendibite–diopside rock are diopside granulite with phlogopite books at 0.6m below and amphibole–phlogopite rock at 0.9m above. The latter is a relatively coarse intergrowth of phlogopite and calcic clinoamphibole in which diopside occurs sporadically, mostly included in the amphibole.

Important constituents of the serendibite–diopside rock are apatite, calcite, pargasite, and secondary phyllosilicates resembling sericite and chlorite, while scapolite, tourmaline, grandidierite, phlogopite, sulfide, sinhalite (?), and spinel are rare. Serendibite is deep blue in hand specimen, while in thin section it forms pale-blue polysynthetically twinned grains up to 1cm across with highly irregular outlines. Preferred orientation of the grains is implied by parallelism of the twin lamellae from grain to grain. Serendibite is partly replaced by a birefringent material in which traces of the twinning lamellae are preserved. A similar material replaces serendibite at Johnsburg (Grew et al., in press). Diopside occurs as inclusions in serendibite and as a granular matrix (grains mostly ≤0.5cm) to it. Patches and overgrowths of pargasite are locally developed in and around diopside, most commonly along contacts with serendibite. Apatite is relatively coarse-grained (≤0.5cm). Larger calcite grains (1–4mm) are mantled and penetrated by a phyllosilicate; these intergrowths may have resulted from alteration of scapolite. Fresh scapolite in grains ≤1mm across occurs sparingly in and between diopside or calcite and serendibite. Grandidierite, spinel, and phlogopite occur in trace amounts within serendibite and appear to have formed from serendibite breakdown. Tourmaline forms irregular, poikilitic patches around serendibite and in places, margins around apatite enclosed in serendibite. A mineral tentatively identified as sinhalite occurs with spinel in serendibite.

Textures suggest a 3-stage history for the serendibite-diopside rock: (1) primary serendibite-diopside ± scapolite–apatite assemblages; (2) secondary assemblages with grandidierite, tourmaline, pargasite, spinel and/or phlogopite which could have formed by reactions such as serendibite + diopside + Na₂O + K₂O + H₂O + CO₂ = grandidierite + pargasite + calcite + B₂O₃ (see Grew et al., in press); and (3) alteration to fine-grained phyllosilicates. The stage 2 minerals, notably grandidierite, are also characteristic of the Johnsburg serendibite-diopside rocks and thus we infer that a second high-temperature event affected the Russell locality. Conditions of formation of the primary serendibite-diopside assemblage could be 660–750°C and 6.7–7.4 kbar, values estimated at nearby localities (maps of Bohlen et al., 1985; Edwards and Essene's, 1988, 700°C isotherm passes close to the locality), and consistent with conditions inferred for serendibite at other localities (Grew et al., in press). The core was drilled about 1km northwest of Buddington's (1963) isograd marking the northern limit for orthopyroxene in amphibolite, implying near granulite-facies conditions for serendibite at Russell, that is, somewhat lower temperatures than the clearly granulite-facies Johnsburg deposit.

Serendibite and associated minerals (1–2 grains each) were analysed with a wavelength-dispersive MAC 400s electron microprobe at the University of Maine (procedure of Yates and Howd, 1988) (Table 1). Assuming that the boron content is similar to the values measured in the Johnsburg serendibite (Grew et al., in press), analytical totals for serendibite are reasonable and the formulae approach Ca₂(Mg, Fe)₃Al₄Si₂B₁.5Si₃O₂₀. Compositions of the two analysed grains can be related by the Tschemarks substitution (Mg,Fe) + Si = 2 Al. Compared to serendibite from most other localities (Deer et al., 1978; Nicollet, 1988), the Russell serendibites are magnesian and sodian, but less so than the Johnsburg serendibites. Incorporation of Na in the Russell and Johnsburg serendibites appears to be through the substitution Na + Si = Ca + Al, which is characteristic of the related minerals aeginitite and rhönite (Deer et al., 1978). Diopside compositions are also
related by the Tschermaks substitution. It was not possible to obtain satisfactory analyses of either tourmaline or spinel. Rough values for tourmaline are 34-35 wt.% SiO$_2$, 0% TiO$_2$, 31-32% Al$_2$O$_3$, 1% FeO, 12% MgO, 3.4% CaO, 1.3% Na$_2$O. One spinel is Mg$_{0.9}$Fe$_{0.1}$Al$_2$O$_4$. In terms of Mg/Fe ratio, the minerals increase as follows: spinel < serendibite < pargasite < grandidierite < diopside, and Na/Ca ratio: diopside < serendibite < pargasite < scapolite.

We suggest that the serendibite–diopside rock results from the metamorphism of boron-bearing sediments of evaporitic affinities. The marble-calc-silicate unit that was penetrated by hole 1872 locally hosts anhydrite-rich rocks of probable evaporitic origin. Similar rocks are exposed in the Balmat and Edwards Mines 20 to 30 km away. Moreover, Swihart and Moore (1989) reported that boron isotope compositions of tourmaline in calc-silicate rocks from other localities in the northwest Adirondack Lowlands lie between isotope compositions of boron from normal marine sediments and present-day seawater. Consequently we have reason to infer a marine sedimentary origin, rather than an igneous origin, for the boron in the Russell serendibite. It is possible that the serendibite–diopside rock developed by isochemical metamorphism of a boron-rich calcareous sediment. However, certain features suggest that limited metasomatism may have also played a role in its formation. In particular, the Russell serendibite–diopside rock closely resembles the serendibite–diopside zone in the metasomatic sequence developed between K-feldspar rock and marble at the Johnsburg locality. Such metasomatic rocks are characterized by a simple mineralogy although the number of constituents (components) in the rock is fairly large. Only 3 or 4 phases in the Russell rock formed during the first metamorphic stage, but 7 non-
volatile components are needed to describe the phases (serendibite, diopside, apatite, and scapolite): CaO, Na₂O, MgO, Al₂O₃, SiO₂, B₂O₃, and P₂O₅ (phase rule would allow 7 phases to be stable). By analogy with Johnsburg, we suspect that the constituents in the Russell rocks were mobilized, though possibly over distances of 1 m or less. Nonetheless, even such limited mobilization may have been sufficient to concentrate dispersed boron into a thin boron-rich serendibite-diopside rock.

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References


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