A NEW SERENDIBITE LOCALITY IN THE GRENVILLE PROVINCE (ORANGE COUNTY, NEW YORK)

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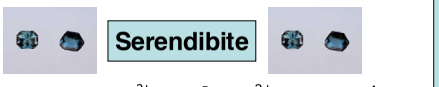
Abstract

A new locality of the rare borosilicate Serendibite ($Ca,Na)_2(Mg,Fe,Al)_6(Si,Al,B)_6O_{20}$) was discovered during regional sampling for calcite-graphite carbon isotope thermometry of the Franklin Marble. The Mesoproterozoic Franklin Marble consists of a main band that extends ca. 30 km from Orange County, NY into Sussex County, NJ and also has outliers in Warren County, NJ. The serendibite studied is from an unremarkable course-grained calcite marble outcrop 1.8 km from Edenville. Serendibite occurs in layers rich in pargasitic amphibole. This locality is >1/2 km from the nearest mapped intrusive body. Equant serendibite showing polysynthetic twinning occurs with green amphibole, apatite, phlogopite, calcite, scapolite, and sinhalite ($MgAlBO_4$). Some serendibite is altered to uvitic tourmaline. This occurrence of serendibite in a calc-silicate layer of the Franklin Marble of New York joins three other Grenville Province localities: near Johnsburg in the Adirondack Highlands, near Russell in the Adirondack Lowlands, and another possible locality in Orange county (Amity). Serendibite, sinhalite, and tourmaline at this locality most likely result from metamorphism of a boron-rich sedimentary protolith.



$(Ca,Na)_2(Mg,Fe^{3+})_3(Al,Fe^{2+})_{4.5}B_{1.5}Si_8O_{20}$

Serendibite was first described by Prior and Coomaraswamy (1903) in a calc-silicate contact zone. Serendibite is related to the mineral Sapphirine $(Mg,Al)_8(Al,Si)_6O_{20}$ and is named for the ancient Arabic word for Sri Lanka, *Serendib*.

Serendibite ranges in color from pale blue (Fe-poor Serendibite) to almost black (Fe-rich). In thin section, the mineral has blue pleochroism and polysynthetic twinning (See Figure 1).

There are about a dozen reported localities of serendibite, include the famous gem producing mine in Gangapitiya, Sri Lanka (Grew, 1996). It is found in contact aureoles as well as amphibolite- and granulite-facies terrains.

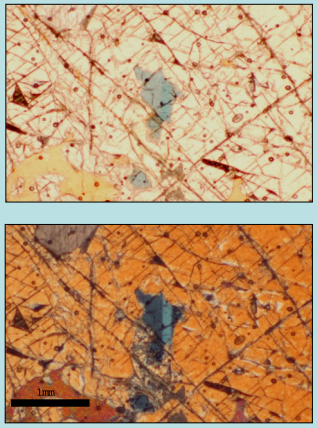


Figure 1. Polysynthetic twinning is common in samples of serendibite from Orange County.

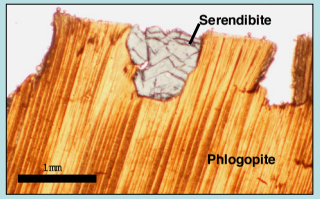


Figure 2. In thin section serendibite is a high relief mineral and a distinctive bright blue color in plane light (here included in phlogopite).

Physical Properties	
Color	Pale-blue, Dark-blue, Pale Yellow
Luster	Vitreous
Hardness	6.5-7
Cleavage	None
Streak	White
□	□
Crystal System	Tricinic
Type	Biaxial
RI values	n =1.701 n =1.703 n =1.706
2V	Measured: 80°, Calculated: 80°
Maximum Birefrengence	=0.005
Surface Relief	High

Grenville Geology of Orange County

The Hudson Highlands in Orange County, New York are part of a belt of Grenville inliers that stretch from the Green Mountains of Vermont to the Llano uplift in Texas and into Mexico. This belt of high-grade metamorphic rocks formed during a series of orogenic events in the Mesoproterozoic. The metamorphic units of the Highlands extend to the New Jersey Highlands to the south, are surrounded by Cambrian sedimentary rocks which grade out into the Devonian sequences common of most of New York State.

The Franklin marble is part of a supracrustal sequence that sits unconformably on the Losee metamorphic suite, which has been correlated to similar ~1.3 Ga arc rocks in the Adirondacks and Green Mountains. The supracrustal sequence is cut by 1.17 Ga intrusive rocks in the Hudson Highlands (Volkert, 2004). The contiguous main band Franklin Marble extends ~30 km into the NJ Highlands, where it hosts the world-class Zn-Fe-Mn Franklin and Sterling Hill deposits. Outcrops of the Franklin Marble contain light grey, medium to course grained calcite or dolomite. Common accessory minerals found in the Franklin marbles include phlogopite, chondrodite, calcic amphibole, clinopyroxene, and large euhedral graphite crystals.

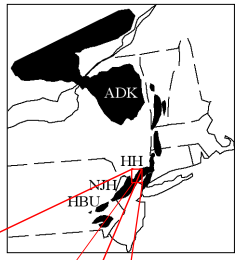
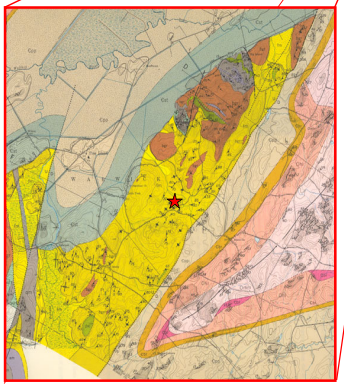
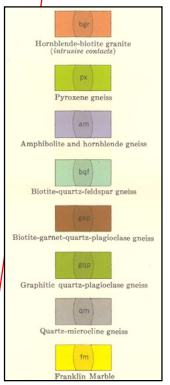
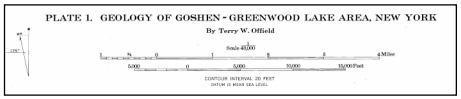


Figure 3. The outcrops containing Serendibite were located about 1.8 km west of Edenville.







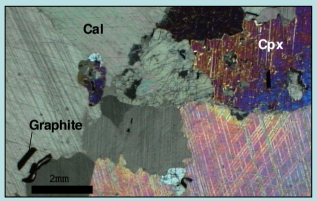


Figure 4. A typical thin section of the Franklin Marble. Calcite is the dominant mineral, however large pyroxene, amphibole crystals also are abundant.

Figure 5. Serendibite was discovered in an amphibole-rich lithology collected from a sequence of unremarkable marble outcrops during sampling for regional calcite-graphite thermometry of the Franklin Marble.

Metamorphism of the Franklin Marble

This locality of serendibite was discovered while sampling the Franklin Marble for regional thermometry. These rocks were crushed and crystals of calcite and graphite were separated then analyzed for their carbon isotope ratio.

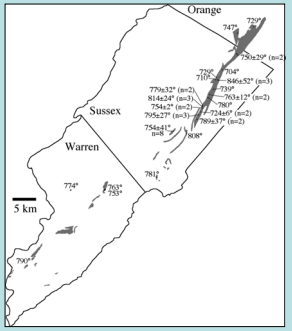


Figure 6. Carbon isotope thermometry in Orange County and the New Jersey Highlands. Grey is outcrop extent of the Franklin Marble.

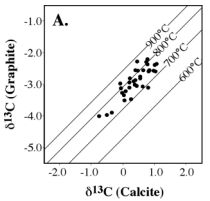


Figure 8. The $^{12}C/^{13}C$ fractionation between graphite and calcite is sensitive to temperature and can be used as a thermometer in high-grade metasediments (Kitchen and Valley, 1995). This technique has been applied to the Franklin Marble and has yielded 769±43 °C for Ottawan metamorphism in the New Jersey Highlands with similar temperatures in Orange County, NY (Peck, Volkert, Meredith, and Rader, *J. Geology in review*).

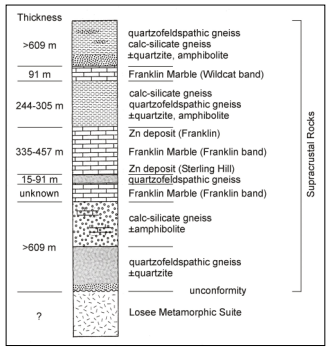


Figure 7. Generalized stratigraphy of the supracrustal sequence in New York and New Jersey (Volkert, 2004). Note that the Franklin Marble can be split into two units: the thick Franklin Band (that hosts the Zn deposits at Franklin and Sterling Hill) and the thinner, barren Wildcat band.

Petrology of Serendibite

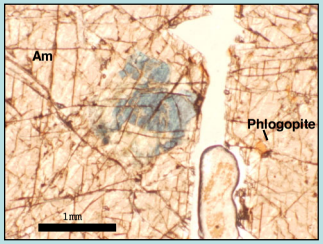


Figure 10. Altered serendibite included in amphibole from the Franklin Marble. This sample also contains trace scapolite and sinhalite ($MgAlBO_4$).

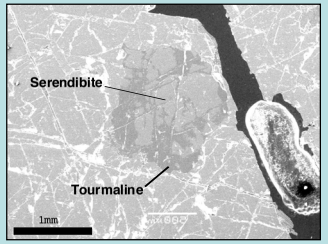


Figure 11. The same crystal as in Fig. 6 viewed using backscattered electrons. Veining of serendibite and alteration to uvitic tourmaline is clearly visible.

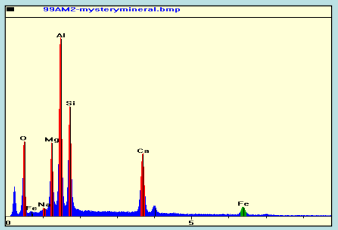


Figure 12. X-ray spectrum of serendibite from the sample collected in Orange County. Abscissa is X-ray energy (in KeV), ordinate is number of counts.

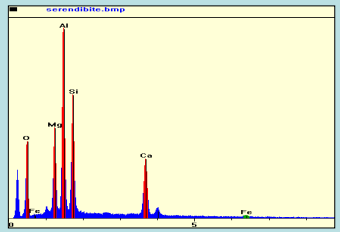


Figure 13. X-ray spectrum of serendibite from the sample collected in Johnsburg, NY. Abscissa is X-ray energy (in KeV), ordinate is number of counts.

Borosilicates in the Grenville Province

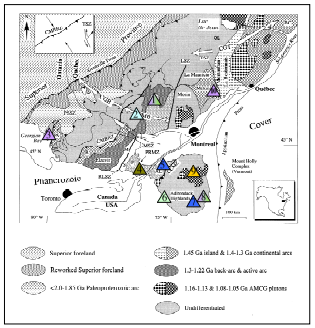
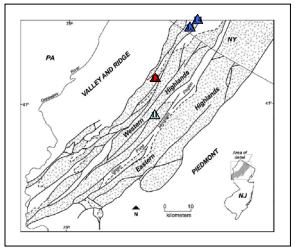


Figure 9. Borosilicates in the southern Grenville Province (base maps from Hamner et al., 2000 and Volkert et al., 2005). "Rare" borosilicates are not uncommon in high-grade rocks of the Grenville Province in Quebec, Ontario, New York, and New Jersey. Some of the protoliths of these rocks are igneous rocks (e.g. the Bondy Gneiss Dome and Moon Mountain), while others are sedimentary.

Field relations and limited boron isotope data suggest that the source of boron at many of these localities is from the protolith or nearby rocks (Palmer and Slack 1989; Swihart and Moore 1989), and not from widespread boron metasomatism.



	Locality	Borosilicate(s)	Protolith/rock-type
1	Bondy Gneiss Dome(QC)	sapphirine+kornerupine	altered volcanic rocks
2	Lac-Ste-Marie (QC)	kornerupine	pelite
3	Central Gneiss Belt(ON)	sapphirine	retrogressed eclogites
4	Frontenac terrane (ON)	grandidierite	pelites
5	Russie (NY)	serendibite	calc-silicate
6	Moose River (NY)	kornerupine (prismantine)	pelite
7	Johnsburg (NY)	serendibite	calc-silicate reaction skarn
8	Moon Mountain (NY)	sapphirine+kornerupine	ultramafic rock
9	Cascade Slide (NY)	harkerite	calc-silicate
10	Maurice(QC)	sapphirine	pelite
11	Franklin (NJ)	B-vesuvuanite	Zn-Mn-Fe oxide ore
12	Mace Mountain (NJ)	kornerupine (prismantine)	pelite
13	Amity? (NJ)	serendibite	?
14	Edenville (NJ, this poster)	serendibite	marble

Grew (1996)

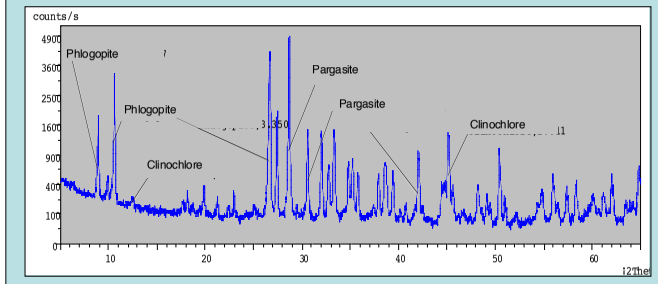


Figure 14. Bulk X-Ray diffraction pattern of serendibite-bearing sample from Orange County. The sample is dominated by pargasitic amphibole and phlogopite.