FLUORINE RESOURCES IN NORTH AMERICA

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OVERVIEW

- CHRONOLOGY
- FLUORSPAR DEPOSIT TYPES
- MAP OF THE UNITED STATES SHOWING MAJOR FAULTS AND AREAS WHERE FLUORINE MINERALS OCCUR
- FLUORSPAR EXPLORATION AREAS IN THE UNITED STATES AND CANADA
- MAP IDENTIFYING APPROXIMATE LOCATION OF EACH DEPOSIT OR MINING DISTRICT
- SPECIFIC DEPOSITS DISCUSSED WITH LOCATION MAPS
- FACTORS TO CONSIDER WHEN EVALUATING DEPOSITS
- REFERENCES AND DATA RESOURCES
CHRONOLOGY

- Native Americans used fluorite for ornaments.
- 1814 – Fluorspar occurrences first reported in eastern United States.
- 1818 – Fluorspar first identified in Illinois.
- 1823 – Earliest recorded use was for hydrofluoric acid.
- 1837 – Used with iron pyrite to smelt copper ore.
- 1842 – First U.S. fluorspar mine was developed, in Hardin County, Illinois.
- 1843 – First fluorspar occurrences were recorded in St. Lawrence area, Newfoundland and Labrador, Canada, Canada.
1869 – Fluorspar discovered in Colorado.
1870 – First fluorspar shipments made from Illinois and Kentucky.
1887 – To this point, fluorspar was used for production of glass, enamels, and HF.
1888 – First U.S. open hearth steel production.
1905 – First Canadian fluorspar mine, in Ontario.
1928 – CFC refrigerants developed.
1945 – Peak U.S. production, 375,000 metric tons.

1974 – Peak Canadian production, 175,000 tons.

1978 – Fluorspar mining at St. Lawrence ends.

1987 – Fluorspar mining at St. Lawrence resumed for about 3 years.


2012 – Klondike II Mine in Kentucky starts up.

2014 – Planned restart of fluorspar mining at St. Lawrence.
Fluorite has been deposited under a wide range of chemical and physical conditions in a variety of geologic environments. The dominant commercial sources are from deposits of hydrothermal origin.

The most common are

- veins,
- mantos (replacement strata-bound deposits), or
- replacement.
DISTRIBUTION OF MAJOR FAULTS AND AREAS WHERE FLUORINE MINERALS OCCUR

LOCATION OF SELECT FLUORSPAR DEPOSITS OR MINING DISTRICTS IN NORTH AMERICA
POSSIBLE FLUORSPAR EXPLORATION TARGETS IN THE UNITED STATES

- ALASKA
  - Lost River, Nome Census Area

- COLORADO
  - Browns Canyon District, Chaffee County
  - Jamestown District, Boulder County
  - Northgate District, Jackson County

- IDAHO
  - Bayhorse District, Custer County
  - Meyers Cove, Lemhi County
POSSIBLE FLUORSPAR EXPLORATION TARGETS IN THE UNITED STATES (cont’d.)

- **ILLINOIS-KENTUCKY FLUORSPAR DISTRICT**
  - Hardin and Pope Counties, Illinois
  - Crittenden and Livingston Counties, Kentucky

- **TENNESSEE**
  - Central Tennessee
  - Eastern Tennessee

- Other States such as Arizona, Montana, Nevada, Texas, and Utah.
POSSIBLE FLUORSPAR EXPLORATION TARGETS IN CANADA

- BRITISH COLUMBIA
  - Liard River

- NEWFOUNDLAND AND LABRADOR
  - St. Lawrence, Burin Peninsula

- NOVA SCOTIA
  - Lake Ainslie, Cape Breton Island
LOST RIVER, ALASKA

- Deposit – A tin-tungsten-fluorine SKARN developed by replacing limestones adjacent to a high level granite intrusion. Fluorspar occurs in veins, veinlets, small pipes, and tabular replacement bodies in the Ordovician limestones and argillaceous limestones.

- Resource – Multiple zones identified, but with a conservative cutoff, Zone 1 has reserves of 13.6 Mt at 20% CaF$_2$ and 0.21% tin. Zone 2 has about 5.7 Mt grading 31% CaF$_2$. (Reserve calculations made prior to passage of NI 43-101.)
MAJOR COLORADO FLUORSPAR DISTRICTS

- Northgate District
- Jamestown District
- Browns Canyon District

States mentioned:
- Wyoming
- Nebraska
- Utah
- Kansas
- Colorado
- New Mexico
- Oklahoma
- Texas
- Arizona

(U.S. Geological Survey logo)
COLORADO FLUORSPAR DISTRICTS

- Colorado produced an estimated 2.3 Mt of fluorspar, which ranks it third behind Illinois and Kentucky.
- Browns Canyon – Veins almost entirely of fluorite and quartz. About 130,000 t of fluorspar produced.
- Jamestown – Most fluorspar deposits are veins and breccia zones. The largest mine was the Burlington, which produced about 700,000 t of acid-grade fluorspar from the 1940s to the 1970s.
- Northgate – Fluorspar occurs as veins in two parallel fault zones about 3 km apart. These are the Fluorine vein system and Fluorspar vein system.
ILLINOIS-KENTUCKY FLUORSPAR DISTRICT
MAJOR STRUCTURAL FEATURES, IL-KY DISTRICT

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ILLINOIS-KENTUCKY FLUORSPAR DISTRICT

- More than 75% of all U.S. fluorspar production.

- Located in southern Illinois and western Kentucky, mostly in a four-county area.

- Geology – Mississippi Valley-type deposits that occur dominantly either as steeply dipping to vertical vein deposits along faults or as low-dipping to nearly flat replacement deposits within a section of mixed Mississippian limestones, sandstones, and shales.
BAYHORSE AND MEYERS COVE, IDAHO
Deposit – Veins and breccia lodes occurring along faults and minor localized fault zones.

Bayhorse Deposit – Measured resources estimated in excess of 2.9 Mt at 36% CaF$_2$ average grade, with a cutoff of 25% CaF$_2$.

The Bayhorse District is likely to contain additional fluorspar resources.

The Meyers Cove area in Lemhi County has additional fluorspar exploration targets.
TENNESSEE DISTRICTS

- Central Tennessee – After the Illinois-Kentucky Fluorspar District, this area may have the largest undiscovered fluorspar resources in the United States.

- Mississippi Valley-type deposits mainly occurring as breccia blankets of fluorspar, barite, sphalerite, and calcite in Lower and Middle Ordovician rocks.

- Area has been extensively explored for zinc, and data on fluorspar occurrences may be available.
East Tennessee – Fluorspar occurs in three northeast-trending belts of limestone or dolomite.

Mississippi Valley-type deposits cut across stratigraphic units or occur as bedded lateral extensions of mineralization along individual limestone units.

Beginning in the mid-1970s, U.S. Borax Co. (now Rio Tinto Borax) conducted an extensive exploration program, but the results apparently were unsatisfactory.
ST. LAWRENCE, BURIN PENINSULA, NEWFOUNDLAND AND LABRADOR

- **Deposit** – More than 40 fluorspar veins have been documented, but not all have been fully mapped. Blue Beach North, Director, and Tarefare Veins have been the source of most past production.

- **Resource** – About 9.1 Mt of reserves (NI 43-101 compliant) in the Canada Fluorspar project area, but additional fluorspar resources are likely to occur in the area.
LAKE AINSLIE, NOVA SCOTIA

- Deposit type – Fluorspar and barite occur on as tabular fissure fillings in faults that cut the Precambrian George River Group and the Mississippian Fisset Brook Formation.

- Resource – The Campbell MacMillan vein is estimated to contain resources of 3.3 Mt at 18.9% CaF$_2$ and 27.8% barite, with an additional 1.1 Mt in other veins. Other barite-fluorspar deposits may exist in unmapped extensions of known veins or in undiscovered veins.
PHOSPHATE MINE LOCATIONS IN NORTH AMERICA
Phosphate rock deposits in North America are primarily fluoroapatite containing about 3.5% fluorine.

Canada – One phosphate mine in Ontario, consists of apatite residuum weathered from a host carbonatite. Fluorine content 2.5 to 3.0%.


Current U.S. reserves of phosphate rock are estimated at 1.4 billion tons, which contain about 101 Mt of 100% CaF$_2$ equivalent.
SOME FACTORS TO CONSIDER WHEN EVALUATING DEPOSITS

- GEOGRAPHIC FACTORS
  - Access to transportation.
  - Accessibility for exploration.
  - Distance from sources of labor.

- GEOLOGIC FACTORS
  - Size, shape, and depth of the deposit.
  - Reserves, including tonnage and grade.
  - Mineralogy of deposit – grain size, impurities, possible byproducts, and suitability of the ore for beneficiation.
SOME FACTORS TO CONSIDER WHEN EVALUATING DEPOSITS (cont’d.)

- **ECONOMIC AND ENVIRONMENTAL FACTORS**
  - Marketing costs.
  - Environmental and political acceptability.
  - Acquisition costs, royalty payments, taxes, duties, and legal costs.
CONCLUSIONS

- There still exist substantial fluorine/fluorspar resources in Canada and the United States.

- Many of the deposits previously identified were deemed uneconomic.

- Factors working against some deposits were low grades, distance to markets, and processing problems.
CONCLUSIONS (cont’d.)

- The economics may have changed for some of these deposits as a result of higher fluorspar prices.

- Future exploration should be in areas with past production. Extensions of known fluorspar bodies should be explored along strike and at depth.
DATA RESOURCES AND REFERENCES

DATA RESOURCES AND REFERENCES (cont’d.)

