CRYSTALLINE FLAKE GRAPHITE P04

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IDENTIFICATION

SYNONYM: Disseminated flake graphite deposits.

COMMODITY: Crystalline flake graphite and crystalline graphite powder.

EXAMPLES (British Columbia (MINFILE #) - *Canada/International*): AA prospect (092M 017), Black Crystal (82FNW260), Mon (093N 203); *Lac Knife deposit, Asbury Graphite mine and Peerless Mine (Quebec, Canada), Graphite Lake and Black Donald mines (Ontario, Canada); American Graphite Company mine (New York State, USA).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Disseminated flakes graphite deposits are commonly hosted by porphyroblastic and granoblastic marbles, paragneisses and quartzites. Alumina-rich paragneisses and marbles in upper amphibolite or granulite grade metamorphic terrains are the most favourable host rocks. Highest grades are commonly associated with rocks located at the contacts between marbles and paragneisses and deposits are thickest within fold crests. Minor feldspathic intrusions, pegmatites and iron formations also contain disseminated flake graphite.

TECTONIC SETTINGS: May be found in any setting with favourable paleo-environment for accumulation and preservation of organic materials, such as intracratonic or continental margin-type basins.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Metasedimentary belts of granulite or upper amphibolite facies invaded by igneous rocks.

AGE OF MINERALIZATION: Known deposits are mostly of Precambrian age, but could be of any age.

HOST/ASSOCIATED ROCK TYPES: Marbles, paragneisses, quartzites, magnetite-graphite iron formations, clinopyroxenites, amphibolites and pegmatites can host flake graphite deposits. Associated lithologies are orthogneisses, charnockites, orthopyroxenites, amphibolites, granulites and variety of intrusive rocks.

DEPOSIT FORM: Stratiform lens-shaped or saddle-shaped. Individual, economically significant deposits are several metres to tens of metres thick and hundreds of metres in strike length.

TEXTURE/STRUCTURE: Strong foliation, schistosity and lepidoblastic texture for paragneiss and schists. Granoblastic, equigranular or porphyroblastic textures in marbles.

ORE MINERALOGY [Principal and *subordinate*]: Crystalline flake graphite ± *microcrystalline graphite.*

GANGUE MINERALOGY [Principal and *subordinate*]: In carbonate-hosted graphite deposits: calcite, clinopyroxene, pyrite and other sulphides ± *dolomite* ± *anorthite* ± *chlorite* ± *clinozoisite* ± *zoisite* ± *garnet.* In paragneiss-hosted graphite deposits: feldspar, quartz, biotite, ± clinopyroxene ± garnet ± sillimanite ± kyanite ± sulphides ± *clinozoisite* ± scapolite ± *secondary gypsum.*

ALTERATION MINERALOGY: Chlorite, prehnite, zoisite and clinozoisite are common retrograde minerals in porphyroblastic marbles.

WEATHERING: Jarosite is a common weathering product of disseminated pyrite-bearing, gneiss-hosted graphite deposits.

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ORE CONTROLS: Low grade, large tonnage deposits are hosted mainly by paragneisses and are stratabound. Higher grade portions of these deposits are commonly located in fold crests; along paragneiss-marble, quartzite-marble and quartzite-paragneiss contacts; or along other zones that acted as channels for retrograde metamorphic fluids.

GENETIC MODELS: Low-grade, stratabound and stratiform deposits are believed to be a product of graphitization of the organic material within pre-metamorphic protolith (carbonates and shales). The crystallinity of graphite is linked to the degree of metamorphism. Higher grade portions of these deposits are usually structurally controlled, and were probably enriched during the retrograde phase of the regional or contact metamorphism. Late graphite precipitation (enrichment) may have been triggered by internal or external buffering or fluid mixing.

ASSOCIATED DEPOSIT TYPES: Commonly associated with vein-graphite deposits (P05).

COMMENTS: Can be spatially associated with kyanite, sillimanite, mica and garnet (P02), dimension stone (R03), wollastonite skarn (K09) and abyssal (ceramic) pegmatite (Q04) deposits.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Graphite concentrations in residual soils and stream beds. Geochemical trace element methods were pioneered in USSR although these methods do not rival with geophysical methods in effectiveness.

GEOPHYSICAL SIGNATURE: Effective methods for detecting high grade mineralization (where at least locally the individual flakes are touching) are airborne EM, ground VLF and other EM methods. Induced polarisation, applied potential and self potential are also used, although IP is considered relatively expensive and in many cases too sensitive.

OTHER EXPLORATION GUIDES: Graphite deposits commonly form clusters. Overall quality of graphite flake increases with the intensity of regional metamorphism. Metasedimentary rocks of upper amphibolite or granulite facies represent the best exploration ground. Traces of graphite within a metasedimentary sequence indicate that the oxidation-reduction conditions were favourable for the preservation of graphite deposits. High-grade ores are associated with fold crests and contacts between adjacent lithological units. In some regions, blue quartz is found in close spatial association with crystalline-flake graphite deposits and could be considered as an empirical indirect indicator of favourable environment for graphite exploration.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Grade and tonnage of producing mines and developed prospects varies substantially. The median grade and size is 9.0% and 2 400 000 tonnes respectively (Bliss and Sutphin, 1992). Depending on market conditions, large deposits containing high proportions of coarse flakes, which can be easily liberated, may be economic with grades as low as 4%.

ECONOMIC LIMITATIONS: Price of the commercial concentrate is determined by flake size, degree of crystallinity (toughness), graphitic carbon content, ash content and type of the impurities. Crystalline flake graphite is commonly chemically-and heat-treated to enhance its properties. Depending on the applications, the most common limiting technical parameters are the carbon content, the diameter of the graphite flakes, the degree of crystallinity (which is related to the flake toughness), the type of impurities and the ash content. Metallurgical and consumer tests are therefore required to market flake graphite.

END USES: Main uses are in refractors, lubricants, brake linings, foundry moulds and dressings, crucibles, electrodes, pencils and others. Graphite use in non-traditional applications, such as expanded graphite and graphite foils, is increasing, while the demand for use in refractors is highly cyclical.

IMPORTANCE: Flake graphite can be substituted for in most of its applications, however substitute materials are more expensive and do not perform as well.

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