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GREIGITE FROM THE LOJANE CHROMIUM DEPOSIT, MACEDONIA

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INTRODUCTION

In 1956, during a study of the paragenesis of the sulfide mineralization in the Lojane ore deposit, the author discovered an unknown, highly magnetic, pink colored mineral which had formed during the same paragenetic stage as the stibnite. Although very fine-grained and intimately intergrown with stibnite, it was possible to concentrate a small fraction for mineralogical studies by magnetic means. A quantitative chemical analysis on the two hundred milligram quantity recovered was inconclusive; the sum of all analyzed components was only 95.04%.

From the data obtained the author could not identify the phase and it was believed the compound was a new mineral, provisionally called "mineral X" (Radusinovic, 1956).

In the recent papers by Polushkin and Sidorenko (1963) and by Skinner, Erd and Grimaldi (1964), a mineral has been described with general features identical to those of "mineral X." Polushkin and Sidorenko named the mineral melnikovite, Skinner *et al.* named it greigite. It is the opinion of the author that greigite should be considered as the correct name, because it represents an entirely new mineral species (Fe_3S_4), while the name melnikovite was already accepted for a morphological variety of FeS_2 (Doss, 1912 a, b).

According to the data published to date, greigite formed under typically sedimentary conditions. In Lojane, however, greigite is found in hydrothermal veins and in same paragenesis as the As and Sb sulfides.

GEOLOGY OF THE LOJANE ORE DEPOSIT.

The Lojane chromium deposit is located about 40 km north of Skoplje, Macedonia, in southeast Yugoslavia. Mineral veins containing the sulfides of As and Sb, together with Ni, Co and U, were discovered during exploitation of the chromium deposit.

The Lojane deposit is in the so-called "Vardar Zone" structural unit. Following a geosynclinal development up to the end of the Mesozoic era, folding commenced in the Tertiary, during the Post-Gossau phase, with the formation of imbricate structures oriented in a NW-SE direction.

Local structures in the deposit, representing only a small portion of the Vardar Zone, have directions coincident with the orientation of the zone. A number of tectonic stages, both before and after formation of the deposit can be readily identified. A number of deep dislocations were formed before mineralization and along these dislocations rhyolites were introduced. The hydrothermal solutions that later deposited the As and Sb ore minerals were also introduced along the same dislocations. Post mineralization tectonics formed a system of dislocations at right angles to the general structures, and along these later dislocations portions of the ore bodies have been displaced.

Country rocks are serpentinites and serpentitized peridotites intruded by granites, syenites and rhyolites. Some lherzolite bodies can be found within the serpentinites, and dunites occur around the chromite ore bodies. The granites are of very limited development, generally in the form of small intrusions and apophyses, and, locally, within a single body, grading completely into syenite. Rhyolites are much more common and in the immediate vicinity of the sulfide ore bodies have been highly hydrothermally altered.

The chromite ore bodies are within the serpentinites and were formed long before the sulfide mineralization. They are usually separated from the sulfide bodies, but in rare cases they are intersected and replaced by the later sulfide veins and veinlets. It is believed the chromite mineralization occurred in the Paleozoic era.

The sulfide ore bodies are concentrated in the contact zones between the serpentinites and rhyolites. They are generally vein-type bodies, but some impregnations and lens-like bodies are also present. Along the contact zone the ore bodies have a regular shape, but those within the serpentinites tend to be dispersed into numerous isolated bodies with highly variable shapes and locations.

The sulfide mineralization belongs to the Alpine metallogenic epoch, supposedly of Tertiary age, although no geochronologic data are available.

The sulfide mineralogy is relatively simple. The most common minerals are stibnite and realgar. Pyrite, bravoite, vaesite, marcasite, orpiment and greigite are also present, but in minor quantities. Although the sulfide ore veins are locally strongly radioactive, no separate uranium mineral has been identified, and it is supposed that uranium appears in the form of "sooty" pitchblende. Pyrite and bravoite are sparse but wide-

spread, whereas marcasite, orpiment, vaesite and greigite occur in local concentrations. The gangue minerals are quartz and dolomite, with argillaceous material, principally montmorillonite, locally present.

Relicts of chromite and magnetite can in places be found with the sulfide minerals, but only in trace amounts.

GREIGITE

Greigite has been found dispersed, in very small quantities, throughout the ore bodies of the Lojane mine. In most cases it occurs in the form of

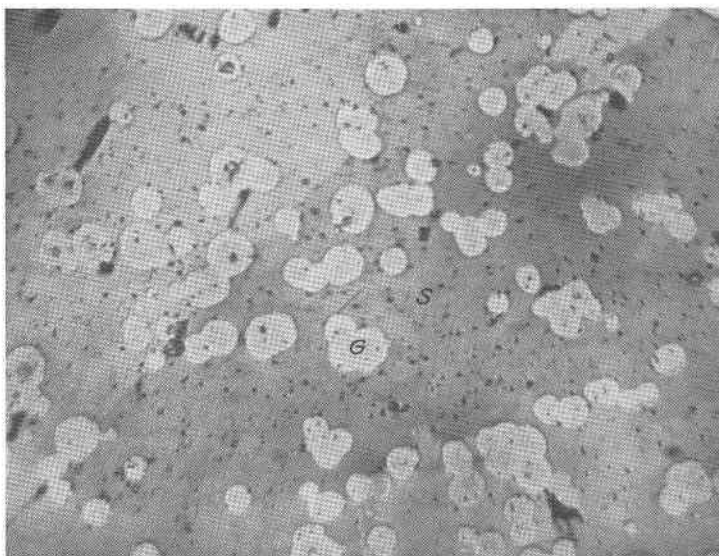


FIG. 1. Greigite (white) occurring as globules in stibnite (gray). Immersion, 260X.

fine-grained globular aggregates within stibnite (Fig. 1). It also occurs within fractures in stibnite and, rarely in the gangue minerals. The inclusions of greigite in stibnite and gangue minerals are irregularly dispersed. The size of the inclusions is highly variable, ranging from a few microns up to a few tenths of a millimeter, though the larger sizes are extremely rare. Within the larger inclusions there is a tendency for development of idiomorphic forms, (010) and (111) faces being clearly identifiable under the binocular. The various ways in which greigite occurs in intergrowths with stibnite are illustrated in Figs. 1 to 4.

On polished surfaces greigite has a pale pink color and somewhat greater relief than stibnite. Although easily polished, a completely scratch-free surface was never obtained. No cleavage was observed, and the mineral

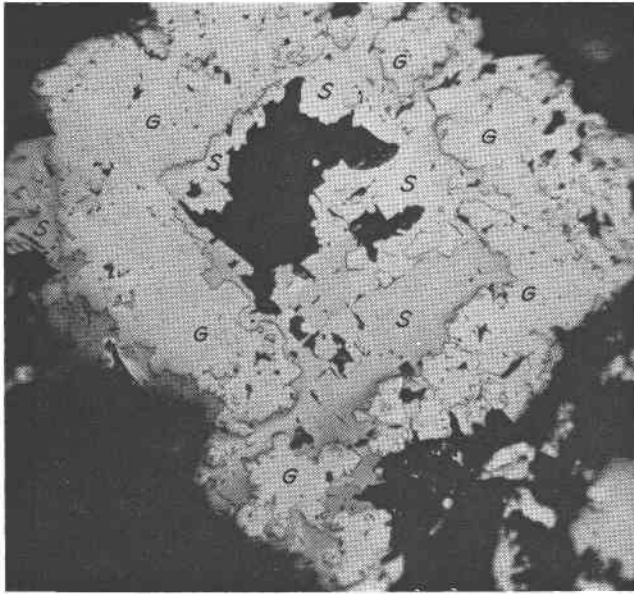


FIG. 2. Greigite (light gray), showing a tendency to develop idiomorphic crystals, surrounded by stibnite (gray, with lower relief). Immersion, 80X.

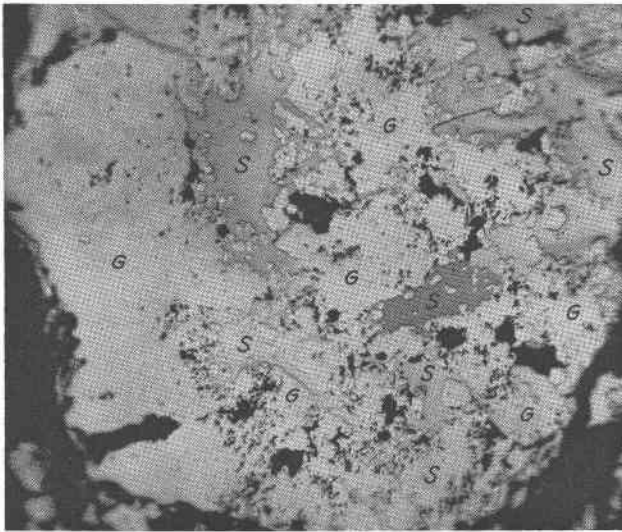


FIG. 3. Greigite (light gray, with pronounced relief), corroded by stibnite (light to dark gray due to pleochroism); Immersion, 80X.

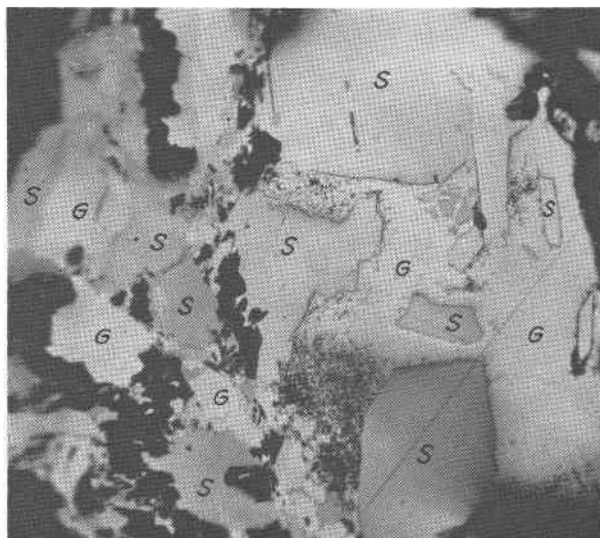


FIG. 4. Greigite (light gray, pronounced relief) intergrown with stibnite (gray). Immersion, 120X.

is optically isotropic, similar to bravoite and minerals of the linnacite group. From the optical features alone greigite might easily be misidentified as one of the Ni-Co minerals.

The fine grain size of the greigite, and its intimate intergrowth with stibnite, prevented all attempts to separate adequate quantities for analysis. Accordingly, the exact chemical composition could not be determined. The result of a chemical analysis of the concentrate is presented in Table 1.

The Sb and As reported in the analysis are due to impurities of stibnite

TABLE I. QUANTITATIVE CHEMICAL ANALYSIS OF GREIGITE CONCENTRATE

Constituent	(200 mg sample)	Percentage
Fe		49.50
S		37.53
Sb		3.23
As		1.04
Ni		0.22
Acid insoluble		3.52
Total		95.04

Analysis performed in the chemical laboratory at the Institute for Nuclear Raw Materials.

TABLE II. SEMI-QUANTITATIVE SPECTROCHEMICAL ANALYSIS

Constituent	Concentration, ppm
Fe	major
Mn	20
Pb	traces
As	1000
Sb	1780
Mo	10
Cu	1
Ni	238
Co	12
Ba	traces
Sr	13
Ti	traces
U	traces
Ca	100
Mg	1000
Si	1000
Al	3160

Analyzed by S. Maksimovic.

and realgar. The Ni is possibly due to isomorphic replacement of the ferrous iron in the greigite structure. This suggestion is supported by the observation that nickel influences the color of greigite, the characteristic pink color being more pronounced with an increased Ni content.

TABLE III. X-RAY POWDER DIFFRACTION DATA FOR GREIGITE FROM LOJANE CHROMIUM DEPOSIT

Measurements made with Fe K α radiation. Intensities (I) estimated visually.		
I	d Å	hkl
3	3.52	220
10	2.98	311
5	2.48	400
1	2.26	331
1	1.99	422
3	1.90	333, 511
9	1.74	440
1	1.43	444
1	1.29	731, 553
1	1.23	800
2	1.10	840
3	0.93	10, 4, 0.

Trace elements in the concentrate were determined by semi-quantitative spectrographic analysis with the results presented in Table 2.

Because of the very small quantity of greigite concentrate, the only physical properties determined were microhardness, specific gravity and unit cell edge.

Microhardness was measured with a Leitz durimeter, yielding a Vickers hardness of 312 ± 24 kg/mm², corresponding to 4.5 on the Mohs scale.

The specific gravity was determined by the hydrostatic balance method, giving a value of 4.005 ± 0.015 .

X-ray powder diffraction data are presented in Table 3 and yield a unit cell edge of 9.878 ± 0.004 Å.

The *d* values obtained by X-ray powder diffraction are in good agreement with those given by Skinner *et al.* (1964) and by Polushkin and Sidorenko (1963). The same is true for the unit cell dimension.

PARAGENESIS

From a paragenetic study it can be concluded that greigite formed in two generations,—in the form of relatively large individual crystals which are corroded by stibnite, and in the form of very fine inclusions and globular aggregates which can be found in fractures in the stibnite. The paragenetic relation between greigite and realgar are not clear however, because the two have not been observed in contact. Because realgar is later than stibnite, it can be concluded that greigite was deposited before the realgar in the hydrothermal process.

From the evidence presented greigite can be assigned to the epithermal phase of deposition in the hydrothermal history of the Lojane sulfide deposit.

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