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DONHARRISITE, NICKEL–MERCURY SULFIDE, A NEW MINERAL SPECIES FROM LEOGANG, SALZBURG PROVINCE, AUSTRIA*

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ABSTRACT

Donharrisite, ideally $Ni_8Hg_3S_9$, is a new mineral species found on a museum specimen from the former Erasmus mine, Schwarzleo mining district, Leogang, Salzburg Province, Austria. The specimen is probably taken from a stratabound carbonate-hosted Pb–Ag–Hg ore. The new mineral species occurs as brownish metallic, mica-like flakes up to 1 mm^2 by 0.1 mm thick, associated with cinnabar, native mercury, galena and trace amounts of sphalerite, tennantite, chalcopyrite, polydymite and pyrite, on slickensided dolostone. It is brittle, opaque, with a brownish grey streak, a perfect cleavage parallel {001} and a pronounced conchoidal fracture. VHN_5 = 47 (av. of 7), D_{calc} = 5.18 g/cm^3 for the ideal formula, and 5.17 g/cm^3 for the empirical formula with Z = 2. In reflected light, the mineral is creamy white with a yellowish tint in air, and creamy white in oil. Anisotropism, in greyish colors, is distinct in both air and oil. Reflectance spectra and color values for two grains are tabulated. Electron-microprobe analyses show very little variation in chemical composition; the mean values for 7 analyses are: Ni 35.2, Hg 43.3, S 20.6, total 99.1 wt.%. The empirical formula (on the basis of 20 atoms) is $Ni_{8.22}Hg_{2.96}S_{8.82}$. Donharrisite is monoclinic, a 11.66(3), b 6.91(1), c 10.92(3) Å, β 97.43(20)°, space group $C2/m$, $C2$ or Cm. The strongest six X-ray powder-diffraction lines [d in Å (I)(hkl)] are: 5.75(70)(200), 5.09(70)(111), 3.71(50)(202), 3.33(60)($\bar{3}$11), 2.683(60)($\bar{4}$02,$\bar{2}$22) and 2.547(100)(222). The name honors Dr. Donald C. Harris for his major contributions to the mineralogy of ores.

Keywords: donharrisite, nickel–mercury sulfide, new mineral species, Erasmus mine, Leogang, Salzburg Province, Austria, electron-microprobe analyses, X-ray data, reflectance data.

SOMMAIRE

La donharrisite, nouvelle espèce minérale dont la formule idéale est $Ni_8Hg_3S_9$, a été découverte sur un spécimen de musée provenant de la mine Erasmus, maintenant abandonnée, dans le camp minier de Schwarzleo (Leogang, province de Salzbourg, Autriche). L'échantillon proviendrait d'un minerai de Pb–Ag–Hg stratifié dans une séquence carbonatée. La donharrisite, en plaquettes micacées brun métallique qui atteignent une dimension de 1 × 1 × 0.1 mm, définit une association avec cinabre, mercure natif, galène et, en quantités accessoires, sphalérite, tennantite, chalcopyrite, polydymite et pyrite le long des plans de glissement dans la dolomie. Elle est cassante et opaque, et possède une rayure gris brunâtre, un clivage {001} parfait et une cassure conchoïdale. La dureté VHN_5 est de 47 (moyenne de 7 mesures); D_{calc} = 5.18 pour la formule idéale, 5.17 pour la formule empirique, avec Z = 2. En lumière réfléchie, la donharrisite est blanc crémeux avec teinte jaunâtre dans l'air, et blanc crémeux dans l'huile. Elle est distinctement anisotrope dans l'air et dans l'huile, en teintes grisâtres. Nous présentons les spectres de réflectance et les valeurs de la couleur pour deux grains. Les analyses à la microsonde électronique révèlent très peu de variation en composition chimique: Ni 35.2, Hg 43.3, S 20.6, total 99.1% (en poids; moyenne de 7 analyses). La formule empirique, en supposant 20 atomes, est $Ni_{8.22}Hg_{2.96}S_{8.82}$. Monoclinique, a 11.66(3), b 6.91(1), c 10.92(3) Å, β 97.43(20)°, groupe spatial $C2/m$, $C2$ ou Cm. Les six raies les plus intenses du cliché de diffraction X (méthode des poudres) [d en Å (I)(hkl)] sont: 5.75(70)(200), 5.09(70)(111), 3.71(50)(202), 3.33(60)($\bar{3}$11), 2.683(60)($\bar{4}$02,$\bar{2}$22) et 2.547(100)(222). Le nom honore M. Donald C. Harris pour ses contributions importantes à la minéralogie des minerais.

(Traduit par la Rédaction)

Mots-clés: donharrisite, nouvelle espèce minérale, sulfure de nickel et de mercure, mine Erasmus, Leogang, province de Salzbourg, Autriche, données à la microsonde électronique, données de diffraction X, données de réflectance.

INTRODUCTION

During an extensive study of precious-metal miner-

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alization in the Northern Greywacke Zone, a metamorphosed sequence of various Paleozoic sedimentary and volcanic rocks in Austria, a detailed examination of the polymetallic deposits near Leogang was undertaken (Lengauer 1988). To determine the mineralogy of the ores, both recently collected and museum specimens were examined. A single specimen from the mineral collections of the Landesmuseum Joanneum, Graz, in the Province of Styria, was found to contain the new mineral *donharrisite*, which is described here. The specimen, Inv. No. LMJ-210, previously labeled as "Amalgam", had been acquired by the museum before 1834; a second and much older accompanying label indicates that the specimen was originally from the collection of a Mr. Lenz. The new mineral is named for Dr. Donald C. Harris, Geological Survey of Canada, Ottawa, for his prominent contributions to ore mineralogy. Both the mineral and name have been accepted by the Commission on New Minerals and Mineral Names, I.M.A.

The holotype specimen (9 × 7 × 2.5 cm, and weighing 276 g) plus several tiny chips are held in the Landesmuseum Joanneum in Graz. Tiny fragments from this specimen have been deposited in the following repositories: Institute of Geosciences (Division of Mineralogy and Petrography), University of Salzburg, Salzburg, Austria; the British Museum (Natural History), London, England; the Royal Ontario Museum, Toronto, and the Systematic Reference Series of the National Mineral Collection, housed at the Geological Survey of Canada, Ottawa (NMC 65207).

The Leogang Mineralization

The polymetallic deposits near Leogang, Austria, are hosted by Upper Silurian – Lower Devonian carbonate rocks rich in organic matter (Haditsch & Mostler 1970). More than 60 different ore-bearing and gangue minerals have been identified in the deposits (Paar & Chen 1986, Paar 1987). A major portion of the mineralization, which consists of complex Cu–Ni–Pb–Hg–Ag-bearing ores, is stratabound. Based on Pb-isotope compositions of galena (V. Köppel, pers. comm. 1987), a Devonian age for this stratabound mineralization can be assumed. According to Lengauer (1987), basic volcanism is considered to be the main source of the mineralization.

Mineralized breccias, as well as vein-type mercurian tennantite-bearing ores, occur along Upper Cretaceous to Early Tertiary (Alpidic) tectonic lineaments. The breccias and veins are interpreted by Lengauer (1987) as results of Paleozoic mineralization that was remobilized and reconcentrated during an early period of the Alpidic orogeny.

The stratabound ore mineralization displays a pronounced vertical zonation, with dominant Cu–Pb, Pb and Pb–Hg mineralization. Minerals noted within the individual zones are given in Table 1. Although an accurate location for the donharrisite-bearing specimen is not given on the accompanying labels, the source is most likely the "cinnabar" (Hg–Pb) zone of the Erasmus mine because the sulfide assemblage and the strongly foliated carbonate matrix are characteristic of this zone.

Electron-Microprobe Analyses

Two grains of donharrisite in a polished section were analyzed at (1) the Geological Survey of Canada using a Cameca CAMEBAX electron microprobe, (2) the British Museum (Natural History) using a Cambridge Instruments Microscan IX electron microprobe, and (3) the Canada Centre for Mineral and Energy Technology (CANMET) using a JEOL 733 electron microprobe. The results agree well for nickel and mercury, but poorly for sulfur. The discrepancies for sulfur occur, at least in part, because of the use of different standards and operating voltages. However, all the sulfur data apparently are erroneous. This finding became evident when cinnabar was analyzed using NiS, FeS, or both as the sulfur standard, and when either NiS or FeS was analyzed using cinnabar as the sulfur standard. It is reasonable to suppose that most matrix-correction procedures deal inadequately with the Hg–S absorption edge; however, the program of Love & Scott (1981), which was tested at the Geological Survey of Canada, gave good sulfur values for cinnabar when NiS was used as the standard. Therefore, the raw Ni, Hg and S X-ray counts obtained on donharrisite from the Cameca CAMEBAX were processed using the correction procedures of Love & Scott (1981). The results (Table 2) are consistent: the average derived from seven analyses corresponds to $Ni_{8.22}Hg_{2.96}S_{8.82}$ or, ideally, $Ni_8Hg_3S_9$, on the bases of 20 atoms and $Z = 2$. However, in view of the

TABLE 1. ORE MINERALS IN POLYMETALLIC ZONES, LEOGANG, SALZBURG PROVINCE

1. Cu-Pb zone	bornite*, chalcopyrite*, tennantite*, polydymite*, millerite*, renierite, mawsonite, colusite, betekhtinite, furutobeite, stromeyerite*, chalcocite, galena
2. Pb zone	galena*, tennantite, polydymite, millerite, gersdorffite
3. Hg-Pb zone	cinnabar*, tennantite*, galena, chalcocite, balkanite, mercurian silver, moschellandsbergite*

* Major constituents in each zone.

TABLE 2. ELECTRON-MICROPROBE DATA ON DONHARRISITE

	1	2	3	4	5	6	7	Av.
Ni, wt.%	35.5	34.3	35.3	35.1	35.9	35.4	35.2	35.2
Hg	43.3	43.3	43.9	43.5	42.8	42.9	43.4	43.3
S	20.7	20.8	20.7	20.7	20.0	20.5	20.7	20.6
Total	99.5	98.4	99.9	99.3	98.7	98.8	99.2	99.1

analytical problems described above, the formula requires confirmation through a crystal-structure analysis. Unfortunately, the available crystals of donharrisite are unsuitable for structure determination (Prof. J. Zemann, written comm., May 1988).

Physical Properties

Donharrisite occurs as isolated, thin, mica-like flakes or laminae (Fig. 1) that have a surface area of up to 1 mm^2 and are about 0.1 mm thick. They are scattered on slickensides and, more rarely, along *s* planes of the holotype specimen, associated with cinnabar, polydymite and trace amounts of galena, sphalerite, chalcopyrite, tennantite and pyrite. Some of the tiny vugs within the dolomite layers contain donharrisite laminae associated with droplets of native mercury. Donharrisite is brown, has a metallic luster and brownish grey streak, and is brittle, with a perfect {001} cleavage. The fracture is conchoidal, and the measured Mohs hardness is about 2. The calculated Mohs hardness is 1.8, based on the equation log Mohs = logVHN – 1/2.5 (Young & Millman 1964) and an average VHN_5 of 47. There is insufficient pure material for a density determination using a Berman balance. The calculated density is 5.18 g/cm^3 for the theoretical formula and 5.17 g/cm^3 for the empirical formula.

Microhardness measurements were made with a Leitz Miniload 2 hardness tester at two institutions, each of which had its own grain-mount polished section. Four indentations were obtained on {001} sections of two different grains at one institution; grain 1 gave VHN_5 ranging from 46.3 to 46.9, and grain 2 gave values in the range 57 – 73.8. The indentations were all found to be slightly fractured. The hardness tester at the other institution gave VHN_5 27.1 to 34.9 based on 3 indentations, all of which are fractured and show concave outlines. The average VHN_5 of all 7 measurements is 47.

Optical Properties

In reflected, plane-polarized light, donharrisite is creamy white (with a slight yellowish tint) in air, and creamy white in oil. It is not pleochroic, is very weakly bireflectant in air, and weakly bireflectant in oil. It is opaque, lacks internal reflections and, in the sections examined, is not twinned. The mineral is distinctly anisotropic, with uncolored rotation tints in shades of grey. With the analyzer rotated from extinction by 3°, the rotation tints are reddish brown to bluish grey (somewhat similar to those of arsenopyrite).

Reflectance measurements were made using the equipment and procedures described by Criddle *et al.* (1983). A WTiC standard, Zeiss no. 314, was used, and the ×40 air and oil objectives were adjusted to provide effective numerical apertures of 0.28. Zeiss oil, N_D = 1.515, was used for immersion measurements, which were made at an ambient temperature of 20°C.

Measurements were confined to two grains in a single polished grain-mount. Because the mineral does not extinguish between crossed polars (in keeping with its metallic nature), it was oriented for measurement with respect to positions of maximum and minimum reflectance at 560 nm. Two areas were

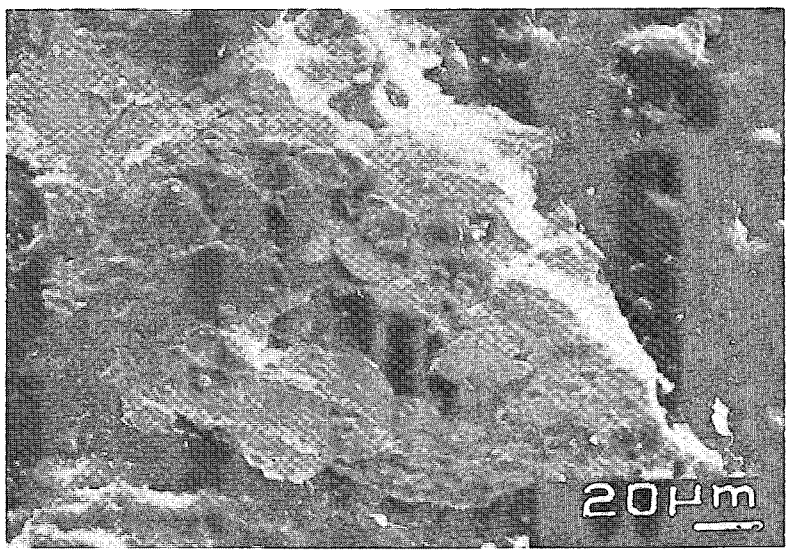

FIG. 1. Secondary electron photomicrograph of donharrisite showing remnants of subhedral polydymite crystals (center).

TABLE 3. REFLECTANCE DATA FOR DONHARRISITE

	1		2		3		1		2		3	
λnm	R_1	R_2	R_1	R_2	R_1	R_2	$^{im}R_1$	$^{im}R_2$	$^{im}R_1$	$^{im}R_2$	$^{im}R_1$	$^{im}R_2$
400	34.0	37.0	33.3	36.5	34.0	36.5	21.8	23.9	21.2	23.7	22.15	24.8
420	34.9	37.9	34.2	37.6	35.2	37.9	22.7	25.6	22.05	24.9	22.9	25.7
440	36.2	39.3	35.2	38.7	36.6	39.3	24.1	27.2	23.2	26.3	24.4	27.0
460	37.9	40.9	36.6	39.9	38.2	40.8	25.9	29.05	24.5	27.8	26.0	28.4
470	*38.75*	*41.7*	*37.3*	*40.7*	*39.15*	*41.7*	*26.7*	*29.8*	*25.1*	*28.4*	*26.9*	*29.3*
480	39.6	42.6	38.1	41.5	40.0	42.6	27.4	30.6	25.7	29.0	27.7	30.0
500	41.3	44.2	39.6	43.0	41.6	44.2	28.95	32.1	26.9	30.3	29.2	31.5
520	42.8	45.7	40.9	44.5	43.2	45.7	30.4	33.55	28.0	31.6	30.6	32.9
540	44.2	47.05	42.2	45.75	44.5	47.05	31.7	34.8	29.1	32.9	31.9	34.3
546	*44.6*	*47.4*	*42.4*	*46.05*	*44.8*	*47.4*	*31.9*	*35.1*	*29.4*	*33.2*	*32.2*	*34.6*
560	45.45	48.3	43.2	46.8	45.7	48.3	32.7	36.0	30.1	34.0	33.0	35.5
580	46.6	49.4	44.2	47.9	46.7	49.4	33.75	37.1	31.0	34.9	33.9	36.5
589	*47.1*	*49.9*	*44.7*	*48.3*	*47.3*	*50.0*	*34.2*	*37.6*	*31.5*	*35.4*	*34.45*	*37.0*
600	47.5	50.4	45.1	48.75	47.7	50.4	34.6	38.0	31.9	35.9	34.9	37.4
620	48.4	51.2	46.0	49.65	48.5	51.15	35.4	38.6	32.7	36.8	35.7	38.1
640	49.2	51.8	46.8	50.4	49.3	51.8	36.1	39.1	33.5	37.5	36.4	38.7
650	*49.5*	*52.0*	*47.1*	*50.7*	*49.5*	*52.0*	*36.4*	*39.3*	*33.9*	*37.9*	*36.6*	*38.9*
660	49.8	52.2	47.45	51.05	49.8	52.2	36.6	39.5	34.2	38.3	36.9	39.0
680	50.4	52.6	48.2	51.7	50.3	52.5	37.2	39.75	35.0	39.0	37.4	39.3
700	51.1	52.85	48.8	52.2	50.9	52.8	37.6	39.8	35.8	39.45	37.9	39.6
Color values: C Illuminant (6774K)												
x	.331	.329	.330	.328	.330	.329	.337	.335	.335	.335	.337	.335
y	.337	.335	.335	.334	.337	.335	.344	.342	.340	.339	.344	.341
Y%	45.0	47.85	42.9	46.45	45.2	47.9	32.3	35.6	29.8	33.6	32.6	35.0
λ_d	578	578	578	578	578	578	578	578	579	578	578	578
P_e%	11.3	10.3	10.3	9.7	11.0	10.3	14.7	13.6	13.1	12.8	14.6	13.4

No. 1 and 3 represent different areas of a same grain which measures approximately 200 x 140 μm in size; No. 2 was measured on a second grain, 60 x 20 μm in size.

measured on the larger grain (areas 1 and 3, Table 3).

Although the dispersion of the reflectance is similar for both grains (Fig. 2), as is their bireflectance, there is a substantial difference of 2% absolute in luminance (Y%). Differences of this order are not uncommon for opaque minerals of variable composition, but there is little evidence of this variability in donharrisite (Table 2). It follows that the differences must be symmetry-related, or the product of measurement error, or a combination of these factors. In reflectance terms, the reproducibility of the measuring equipment used is of the order of ± 0.5% relative, as is evident from the data for the two areas of the larger grain (Table 3). It is unlikely, therefore, that measurement error would be sufficient to account for the differences in R and ^{im}R; the more probable cause is the random orientation of this biaxial mineral.

The dispersion of all the measured spectra are similar, the color values (Table 3) are self-consistent, and the dominant wavelength (578 nm) and excitation purity (10–11%) conform to the perceived yellow color of the mineral. It is significant that optically, the only mineral with which donharrisite might be confused is tuceckite ($Ni_9Sb_2S_8$), although there are differences of dispersion in their reflectances (QDF 2.387, Criddle & Stanley 1986).

X-Ray Studies

Two mica-like flakes of donharrisite were studied by precession methods employing Zr-filtered Mo radiation. One flake was mounted such that a^* is parallel to the rotation axis and the other flake mounted such that b^* is parallel to the rotation axis. The levels collected were $hk0 \rightarrow hk3$, $h0l \rightarrow h2l$ and $0kl \rightarrow 3kl$. The single-crystal films exhibit evidence of multiple crystallites and nodes with tails; these qualitative features are evidence of crystal multiplicity or structural disorder, or both. Although the overall appearance of the films is poor, which hindered interpretation, resolution is sufficient to indicate that donharrisite is monoclinic, with extinction conditions compatible with space groups $C2(5)$, $Cm(8)$ or $C2/m(12)$. The diffraction aspect is $C^*/*$. The unit-cell parameters determined from zero-level precession films are: a 11.65, b 6.90, c 10.89 Å, β 97.25°. Nodes that obey the diffraction conditions for a face-centered lattice are very strong on all precession films and thus predominate in the indexing of the X-ray powder-diffraction pattern (Table 4). The refined unit-cell parameters, a 11.66(3), b 6.91(1), c 10.92(3) Å, β 97.43(20)°, V 872.4(5.1) Å^3, $a:b:c$ = 1.6874:1:1.5803, are based on 15 X-ray powder lines between 3.71 and 1.682 Å for which

unambiguous indexing is possible. All indexed reflections were checked on single-crystal precession films. Numerous 114.6 mm Gandolfi-camera films were prepared from the available material and run with both Fe-filtered Co radiation and Ni-filtered Cu radiation. All films show some degree of preferred orientation, and for the most part are somewhat weak and diffuse. These effects made film measurement difficult and most likely account for the rather large standard deviations reported above.

Acknowledgements

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TABLE 4. X-RAY POWDER DATA FOR DONHARRISITE

Iest	dmeas	dcalc	hkl	Iest	dmeas	dcalc	hkl
70	5.75	5.79	200	10	2.337	2.340	204
		5.42	002			2.336	313
5	5.40	5.40	$\bar{2}01$	5	2.245	2.259	130
		5.35	$\bar{1}11$			2.223	$\bar{1}31$
70	5.09	5.07	111			2.218	420
3b	4.21	4.23	$\bar{2}02$	30	2.220	2.216	$\bar{4}21$
50	3.71	3.72	202			2.204	$\bar{5}11$
20	3.46	3.46	020			2.201	131
60	3.33	3.32	$\bar{3}11$	10	2.134	2.133	421
5	3.177	3.178	$\bar{1}13$			2.127	$\bar{4}22$
10	2.997	2.998	113			2.117	$\bar{4}04$
		2.967	220	10	2.101	2.104	$\bar{1}32$
3	2.928	2.913	022			2.102	511
5	2.889	2.889	$\bar{4}01$	30	2.071	2.079	$\bar{1}15$
60	2.683	2.700	$\bar{4}02$			2.069	$\bar{2}24$
		2.678	$\bar{2}22$			1.923	331
30	2.609	2.613	$\bar{3}13$	10	1.901	1.895	$\bar{6}02$
100	2.547	2.533	222			1.894	133
				20	1.858	1.862	404
				5	1.800	1.805	006
						1.805	$\bar{4}24$
				10	1.743	1.748	602
						1.736	315
				5	1.727	1.728	040
				20	1.682	1.684	620

- 114.6 mm Gandolfi camera employing Fe-filtered Co radiation, ($\lambda CoK\alpha$ = 1.7902 Å)
- film #1043 (measurement) and #1045 (visual estimation of intensities) run at CANMET by Mr. E.J. Murray
- b = broad line
- indexed on a 11.66, b 6.91, c 10.92Å, ß 97.43°

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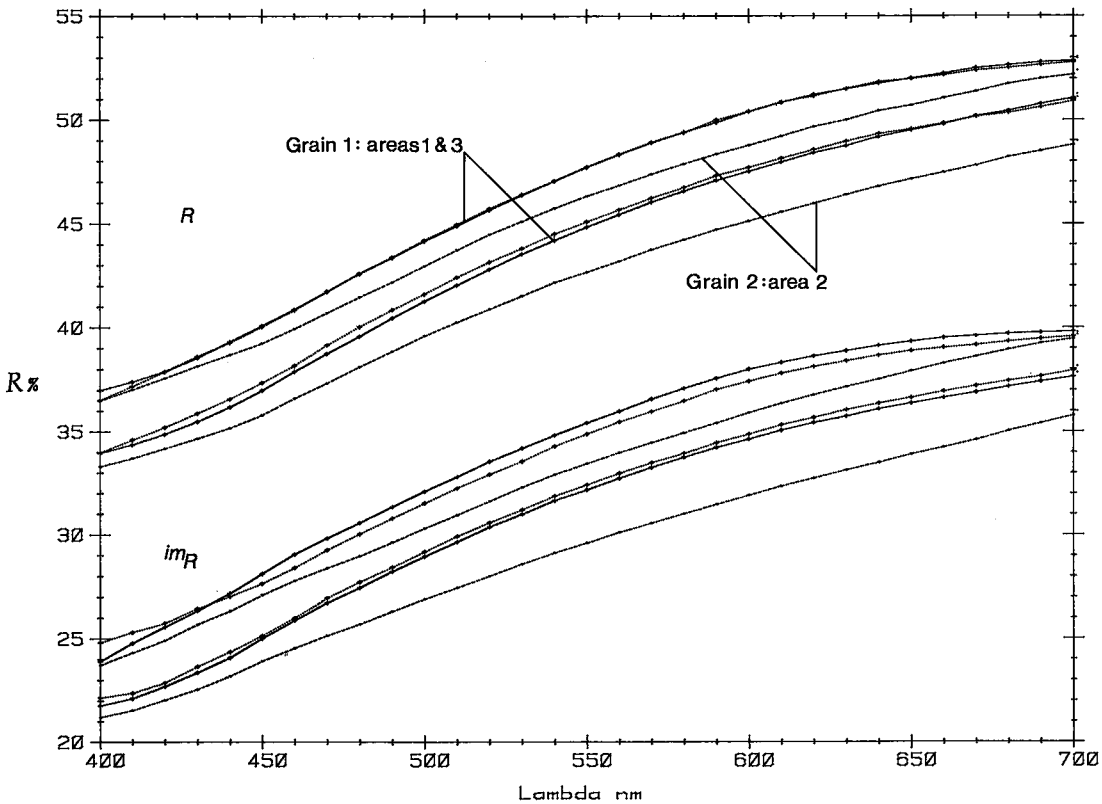

FIG. 2. Reflectance spectra in air and in immersion oil (N_D 1.515) for three areas of donharrisite.

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