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Tučekite, a new antimony analogue of hauchecornite

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TUČEKITE, $Ni_9Sb_2S_8$, was found as microscopic grains in a mineralized Archaean chlorite schist at Kanowna (35° 35′ S., 121° 36′ E.), Western Australia, and in the gold-bearing conglomerates of the Witwatersrand System (26° S., 27° E.), South Africa.

The nickel mineralization at Kanowna is located in metamorphosed basic and ultrabasic rocks of the Morelands Formation, which is part of the Kalgoorlie-Yilgarn succession of the West Australian Archaean shield. The tučekite-bearing mineralization occurs as an approximately 2 cm thick zone of disseminated sulphides in a chlorite schist near its contact with a serpentinized ultramafic intrusive rock. Tučekite is here associated with millerite, pyrite, chalcopyrite, gersdorffite, pentlandite, magnetite, and supergene polydymite. Tučekite occurs as rims and irregular grains partly replacing millerite, and was apparently formed during the later stages of the ore-forming process by reaction of Sb-bearing solutions with millerite.

In the Witwatersrand the mineral was found in a heavy mineral concentrate prepared from ore from the Vaal Reef, Vaal Reefs mine, Klerksdorp (Far West Witwatersrand), and in a mixed concentrate from the Carbon Leader Reef and the Ventersdorp Contact Reef, Western Deep Levels Ltd., Carltonville (West Wits Line). Although rare free grains of tučekite are found, the mineral is more commonly intergrown with gold, and in the Vaal Reef the mineral is also found intergrown with gersdorffite.

Empirical formula of the Kanowna mineral is $(Ni, Fe, Co)_{9\cdot05}(Sb, Bi, Te)_{1\cdot00}(Sb, As)_{1\cdot04}S_8$; that of the Witwatersrand mineral is $(Ni, Fe)_{9\cdot00}(Sb, Bi)_{1\cdot00}(Sb, As)_{1\cdot06}S_8$. The structural formula is assumed to be $Ni^{vi}Ni^{v}_{8}Sb^{vi}Sb^{viii}S^{v}_{4}S^{v}_{4}$; Z = 1. The mineral is opaque, has a metallic lustre, and is pale yellow. Under the microscope in reflected light it is pale brownish-yellow; bireflectance not discernible; anisotropy very strong with deep brown and greyish-blue polarization colours; reflectivity high. Indentation hardness 718 kg/mm^2 (20 g load); 417 kg/mm^2 (10 g load).

Strongest Debye-Scherrer powder-pattern lines of the Witwatersrand mineral are 2·76 (10) 211; 2·38 (8) 112; 2·28 (8b) 221, 310; 1·850 (8) 222; 4·33 (7) 101; 1·793 (7) 400, 302. By analogy with hauchecornite, the pattern can be indexed on a tetragonal unit cell with a = 7·174 Å and c = 5·402 Å; ρ (calc.) = 6·15 g/cm^3. Type material is preserved in the British Museum, London, and the National Museum, Prague (Czechoslovakia).

The full paper appears in the Miniprint section, pp. M21–22.

TUČEKITE, A NEW ANTIMONY ANALOGUE OF HAUCHECORNITE

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INTRODUCTION

The new mineral was found independently by C.E.F. in the Witwatersrand gold-bearing conglomerates and by J.J. in a mineralised Archaean chlorite schist in Western Australia. As the proposals were sent to the I.M.A. Commission on New Minerals and Mineral Names almost simultaneously, the authors agreed to joint authorship. *Both the mineral and name tučekite* (toochekīt)* were approved by the Commission.

The mineral is named in honour of Dr Karel Tuček, C.Sc., Curator of Minerals at the National Museum in Prague, Czechoslovakia.

OCCURRENCE

Tučekite has so far been found at three localities; one in Australia at Kanowna near Kalgoorlie, North-East Coolgardie Goldfield, Central Division, Western Australia (30°35'S, 121°36'E); and two in South Africa - the West Wits Line of the Witwatersrand (26°25'S, 27°30'E), and the Far West Witwatersrand (26°50'S, 26°45'E).

The nickel mineralisation at Kanowna is located in metamorphosed basic and ultrabasic rocks of the Morelands Formation (Williams, 1970), which is part of the Kalgoorlie-Yilgarn succession of the West Australian Archaean shield (Prider, 1965). The tučekite-bearing mineralisation occurs as an approximately 2cm thick zone of disseminated sulphides in a chlorite schist near its contact with a serpentinized ultramafic intrusive rock (R.G. Ashton, pers. comm., 1975).

Tučekite is here associated with millerite, pyrite, chalcopyrite, gersdorffite, pentlandite, magnetite and supergene polydymite. Tučekite occurs as rims and irregular grains partly replacing millerite (fig. 1), and was apparently formed during the later stages of the oreforming process by reaction of Sb-bearing solutions with millerite.

In the Witwatersrand, the mineral was found in a heavy mineral concentrate prepared from ore from the Vaal Reef, Vaal Reefs mine, Klerksdorp (Far West Witwatersrand), and in a mixed concentrate from the Carbon Leader Reef and the Ventersdorp Contact Reef, Western Deep Levels Ltd., Carltonville (West Wits Line). Although rare free grains of tučekite are found, the mineral is more commonly intergrown with gold (fig. 2.); and in the Vaal Reef the mineral is also found intergrown with gersdorffite. Other antimony-bearing *minerals observed in the reefs are dyscrasite,* michenerite, geversite, tetrahedrite, stibnite, sudburyite and stibiopalladinite (Feather and Koen, 1975).

* The diacritical mark over c in the Czech language denotes a change in pronunciation from (ts) to (ch) sound and cannot be omitted; č is considered a letter separate from c.

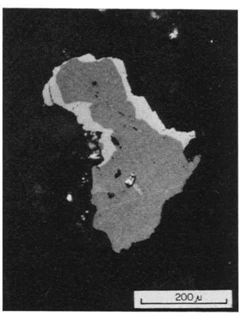

FIG. 1. Tučekite rim around millerite. Kanowna. Sample A 523438, polished section, reflected light, nicols X.

FIG. 2. Tučekite rim around native gold. Witwatersrand. Sample M./76/691, polished mount, reflected light, nicols parallel.

PHYSICAL PROPERTIES

The optical and other physical properties of tučekite from both localities are given in Table I.

A Reichert microphotometer and silicon carbide standard were used for the reflectance determination of the Witwatersrand tučekite; a non-commercial microphotometer and standards comprising silicon and a high reflectivity glass were used for the Kanowna mineral.

The microhardness values of both the Kanowna and Witwatersrand tučekites were determined using Vickers identation hardness testers and stainless steel standards.

The mineral is brittle; no cleavage was observed in polished sections.

Fracture appears to be conchoidal.

Table I: Physical properties of Kanowna and Witwatersrand tučekite.

	Kanowna	Witwatersrand
Colour	pale brass yellow	pale brass yellow
Lustre	metallic	metallic
Colour in reflected light	pale brownish yellow (against millerite)	white with pale yellow-brown tint
Bireflectance	very weak or absent	very weak
Anisotropy	very strong	distinct
Polarisation colours	deep brown to greyish blue	deep brown to greyish blue
Reflectance (%) (in air)		
470 nm	43	
546 nm	48	
590 nm	50	
650 nm	52	
Reflectance (%) (in oil)		
546 nm		32.3
Microhardness (kg/mm^2)		
range	691-746 } 20 g load	302-613 } 10 g load
average	718	417
Calculated density (g/cm^3)	6.18*	6.15

* The calculated density for the Kanowna tučekite is not very reliable, because of unreliable unit-cell data.

CHEMICAL COMPOSITION

The chemical compositions of the Kanowna and Witwatersrand tučekites were investigated using MAC 400S and JEOL JXA-5A electron probe microanalysers, respectively.

Analytical conditions for the MAC 400S (JEOL JXA-5A) were: Accelerating voltage 19.3kV (25kV); approx. specimen current 8nA (50nA); counting time 20 sec. (20sec.); diagnostic lines Ni-Kα, Co-Kα, Fe-Kα, As-Kα, Sb-Lα, Te-Lα, Bi-Lα, S-Kα (Ni-Kα, Fe-Kα, S-Kα, As-Kα, Sb-Lα, Bi-Mα); standards Ni - metal, NiS_2 (metal); Co - metal, CoSbS; Fe - pyrite (analysed chalcopyrite); S - pyrite, NiS_2, CoSbS (analysed chalcopyrite); As - InAs, GaAs (Pd_5As_2); Sb - metal, CoSbS ($PtBi_{1.4}Sb_{0.6}$); Te - metal; Bi - metal ($PtBi_{1.4}Sb_{0.6}$). Data correction: MAGIC-IV Programme of Colby, 1968 (TIM-1 programme of Duncumb and Jones, 1969).

Results of the analyses are given in Table II.

The analytical results, when calculated as 8 sulphur atoms, lead to empirical formulae $(Ni_{8.21}Fe_{0.66}Co_{0.18})(Sb_{0.89}Bi_{0.09}Te_{0.02})(Sb_{0.92}As_{0.12})S_8$, and $(Ni_{8.31}Fe_{0.69})(Sb_{0.95}Bi_{0.05})(Sb_{0.88}As_{0.18})S_8$ for the Kanowna and the Witwatersrand minerals, respectively. The idealised formula is Ni_9SbSbS_8, which corresponds to the antimony analogue of hauchecornite, Ni_9BiSbS_8 (Just, in prep.).

Table II: Chemical composition of Kanowna and Witwatersrand tučekite.

	Kanowna			Witwatersrand		
Element	Range	Analysis* used in calculations	Atoms per unit cell S=8	Range	Average	Atoms per unit cell S=8
Ni	44.37-47.56	47.34	8.21	45.3 -48.9	47.80	8.31
Co	1.01- 1.17	1.06	0.18	n.f.		
Fe	3.61- 4.18	3.61	0.66	2.6 - 4.8	3.75	0.69
As	0.66- 1.82	0.86	0.12	0.86- 1.8	1.34	0.18
Sb	20.55-22.23	21.62	1.81	20.0 -22.9	21.87	1.83
Te	0.04- 0.30	0.30	0.02	n.f.		
Bi	0.00- 1.84	1.84	0.09	0.1 - 3.0	1.02	0.05
S	24.03-27.34	25.19	8.00	24.6 -25.8	25.13	8.00
Sum	96.27-102.62	101.81		98.96-102.6	100.91	

* The analyses were not averaged as not all elements were analysed for in all cases. The analysis selected would be close to average values.

n.f. not found.

X-RAY DIFFRACTION DATA

The small size of the tučekite grains and the intimate intergrowth with other minerals limited the X-ray studies to the Debye-Scherrer powder method. Only very little material could be extracted from the Kanowna samples and so the pattern obtained is very faint, and the discrepancies between measured and calculated d values can therefore be attributed to measuring errors. The pattern obtained on the Witwatersrand material is much sharper, the agreement between measured and calculated d values is good, and the unit-cell parameters are therefore more accurate. In both cases the unit-cell parameters and d values were calculated using a least-squares computer programme and Peacock's (1950) indexing of the hauchecornite pattern. The results are given in Table III.

The space group could not be determined, but similarity with the hauchecornite pattern suggests P4/mmm. The presence of possible superstructures, as reported by Gait and Harris (1972) for the arsenian and tellurian hauchecornites, could not be determined.

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The mineral is assumed to have a structure similar to that determined by Kocman and Nuffield for hauchecornite from Westphalia (see Kocman and Nuffield, 1974, for details). Tučekite differs from hauchecornite in that Sb is dominant in both of the two Group V element sites. The idealised structural formula is therefore $Ni^{vi}Ni_8{}^{v}Sb^{vi}Sb^{viii}S_4{}^{v}S_4{}^{v}$.

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Table III: X-Ray Powder Data for Tučekite

Witwatersrand[1]				Kanowna[2]		
I/I_o	d_{obs}	d_{calc}	hkl	I/I_o	d_{obs}	d_{calc}
7	4.33	4.315	101			
5	3.58	3.587	200			
6	3.21	3.208	210	w	3.19	3.248
2	2.99	2.988	201	w	2.96	2.992
10	2.76	2.758	211	s	2.73	2.766
2	2.52	2.528	102	vw	2.51	2.480
8	2.38	2.384	112	m	2.35	2.347
8b*	2.28	2.296	221	m	2.26	2.297
		2.269	310			
2	2.19	2.187	301			
		2.158	202			
1	2.06	2.066	212			
8	1.850	1.849	222	m	1.841	1.840
7	1.793	1.793	400	mb	1.787	1.784
		1.790	302			
1	1.744	1.746	103			
1	1.734	1.737	312	vw	1.723	1.732
3	1.697	1.691	330	w	1.689	1.671
1	1.657	1.656	411			
½	1.606	1.609	203			
		1.604	420			
2	1.566	1.570	213			
1	1.495	1.494	402			
½	1.464	1.468	223			
		1.463	412			
2b	1.385	1.387	501			
		1.387	431			
		1.379	422			
3	1.343	1.351	004			
		1.335	323			
2	1.299	1.293	521			
2b	1.269	1.271	403			
		1.267	502			
		1.267	432			
		1.264	204			
1	1.225	1.230	530			
2	1.198	1.200	531			
		1.198	423			
		1.196	600			
2	1.152	1.152	611			
½	1.133	1.134	620			
1	1.116	1.117	324			
½	1.094	1.093	541			
3	1.074	1.079	404			
		1.071	523			
2	1.050	1.049	631			
1	1.018	1.016	533			
2	0.997					
1	0.960					
3	0.953					
1	0.946					
1	0.923					
2	0.910					

*b denotes broad line

1. Co-Kα radiation, Fe filter; a 7.174(6) Å, c 5.402(7) Å, V = 278.0 $Å^3$
2. Cu-Kα radiation, Ni filter; a 7.26(5) Å, c 5.28(6) Å, V = 278.3 $Å^3$