

THE STRUCTURAL FORMULA OF AN ANTIGORITE FROM VENEZUELA

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Hess, Smith and Dengo (1952) have described a monomineralic antigorite rock from the vicinity of Caracas, Venezuela, and from a detailed chemical analysis have concluded that the composition "shows a poor fit" with the ideal serpentine formula, $Mg_6Si_4O_{10}(OH)_8$, and is represented better by the more complex formula $Mg_7Si_5O_{13}(OH)_8 \cdot nH_2O$, with $n=1.4$ for the analyzed specimen, but possibly varying between 1 and 3 for other specimens of antigorite. The difficulty of reconciling this formula with the generally accepted kaolin-type structure of antigorite led the writer to re-analyze the chemical data given by Hess et al. In the writer's opinion the results obtained fit reasonably well with the ideal formula, and for the small discrepancies which are found an explanation is suggested.

It must be admitted that no unique and infallible method exists for translating a chemical analysis into a structural formula, especially in the case of silicates. Since the volume of a silicate is largely filled by O and (OH) ions, it is probably best in the first place to scale O+OH to the number of ions in the unit cell or in the structural unit which for serpentine minerals is ideally $Mg_3Si_2O_5(OH)_4$. Table 1 shows that when the number of O atoms is scaled to 9, there are 2.038 Si ions which just exceeds the maximum permissible number by about 2%. If the chemical analysis is accepted as being strictly accurate, then the implication is that about 2% of the O and (OH) sites are vacant, which is not difficult to envisage. The chemical composition is therefore scaled to give 2 Si

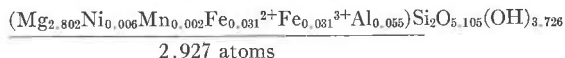
TABLE 1. COMPOSITION OF ANTIGORITE FROM NEAR CARACAS, VENEZUELA

1		2		3	
SiO ₂	43.60	Si	2.038	2.000	
Al ₂ O ₃	1.03	Al	0.057	0.055	
Fe ₂ O ₃	0.90	Fe ³⁺	0.032	0.031	
FeO	0.81	Fe ²⁺	0.032	0.031	
MnO	0.04	Mn	0.002	0.002	2.927
MgO	41.00	Mg	2.855	2.802	
NiO	0.16	Ni	0.006	0.006	
H ₂ O ⁺	12.18	H	3.796	3.726	OH 3.726
		O	9.000	8.831	O 5.105

1. Composition given by Hess, Smith and Dengo, omitting traces of Cr₂O₃, CaO, Na₂O, K₂O and TiO₂, amounting in all to 0.12.
2. Relative numbers of ions based on O=9.000.
3. Relative numbers of ions based on Si=2.000.

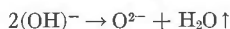
ions per structural unit and the results obtained are given in Table 1, column 3.

The structural formula of the antigorite can then be written



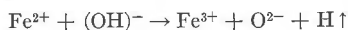
The number of octahedral ions approaches closely to 3 and the small departure from the ideal value is no greater than frequently occurs in minerals. The O ions are slightly in excess of 5 and the (OH) ions slightly below 4. The formula is in good accord with the ideal.

Various explanations may be advanced to interpret these small deviations from the ideal formula, none of which is capable of definite proof. The simplest hypothesis is that a small amount of dehydration of the mineral has occurred, which may be represented symbolically by



If sufficient water is added to bring the number of O+OH ions to 9, namely 0.169 H₂O, the O:(OH) ratio becomes O_{4.936}(OH)_{4.064}. We cannot approach nearer to the ideal 5:4 ratio without considering why the octahedral ions depart from the ideal number 3 and the ideal change +6.

A further contributory factor to the observed composition of the mineral may be connected with the presence of ferric iron. Brindley and Youell (1953) have shown in the case of chamosite, a mineral of kaolinite type containing ferrous iron, that oxidation to a ferric form takes place without change of crystal structure according to the following reaction:



Electrical neutrality is maintained by (OH)⁻ becoming O²⁻, and only H is lost from the lattice, being removed as water by aerial oxidation. This reaction also goes in the direction of increasing the O content and diminishing the (OH) content of the structure; in the present case it can be no more than a contributory factor since the amount of ferric iron is small. It should, however, be mentioned that Holzner (1938) has shown very convincingly the necessity for similar considerations in assessing the composition of iron-bearing chlorites.

In conclusion it may be stated that the composition of the antigorite discussed by Hess et al. can be reconciled satisfactorily with the simple ideal formula and that possible explanations can be given for the small deviations from the ideal composition.

REFERENCES

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A SIMPLE MICROSPECTROSCOPE*

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The microspectroscope, or spectroscopic ocular, has been known to mineralogists for many years, but because of its limited application it has never come into common use in the mineralogical laboratory. The value of the microspectroscope in mineral identification was pointed out by Wherry (1915, 1929), who described the technique employed in its use and recorded the absorption lines and bands for a large number of minerals. The type of instrument used by Wherry consisted of a small direct-vision prism spectroscope designed to replace the conventional microscope ocular. It contained a wave-length scale, and an auxiliary prism permitted the comparison of the mineral spectra with those of

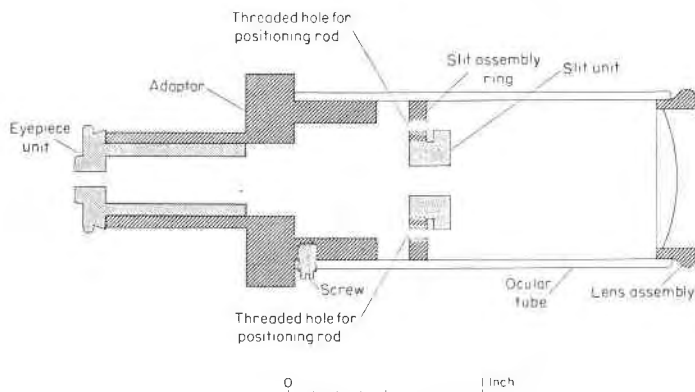


FIG. 1. Sketch showing construction of microspectroscope.

standard solutions. Microspectroscopes of that type, described and illustrated by Chamot and Mason (1948), are now difficult to obtain.

An easily constructed, inexpensive microspectroscope has been designed which the writer has found most useful in detecting the presence of rare earths in minerals. Parts from a small pocket grating spectroscope were combined with a microscope ocular as shown in Fig. 1. The upper lens of a low-power ocular from an old microscope was removed and replaced by a brass adaptor made to hold the eyepiece unit of the

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