THE AMERICAN MINERALOGIST, VOL 53, JULY-AUGUST, 1968

NOMENCLATURE AND CRYSTAL-CHEMISTRY OF AXINITES

E. Sanero, *Università di Genova, Italy* and
G. Gottardi, *Università di Modena, Italy.*

Introduction

Heretofore the nomenclature of axinites was very simple: the only name accepted by everybody was "axinite" itself, sometimes associated with the adjective "manganous". Since most, if not all, axinites are manganous, we felt that this nomenclature was inadequate and could be improved by reintroducing some old names. The nomenclature here proposed has been approved prior to publication by the New Minerals and Mineral Name Commission of the IMA. In this discussion the following names are mentioned:

Axinite (Haüy, 1799, in Dana, 1892, p. 527)
Ferroaxinite (Schaller, in Dana and Ford, 1914)
Manganaxinite (Fromme, 1909)
Tinzenite (Jakob, 1923)
Severginite (Barsanov, 1951)
Manganseverginite (Kurshakova, 1967)

Other obsolete names, which have been used for axinites are listed, for instance, by Hey (1962).

Crystal Chemistry

As a general formula for axinite one can assume

$$H(Ca, Mn, Fe, Mg)_3Al_2BSi_4O_{16}$$

The Mg contents are low. According to Ito and Takeuchi (1952), the atoms (Ca, Mn, Fe, Mg) occupy three independent positions in the crystal structure, one with six-fold coordination and two with ten-fold coordination. The variability of the chemical composition can best be represented in a triangular diagram, whose vertices correspond to pure Ca-, Mn-, (Fe, Mg)-molecules of the above compound. This has been done in Figure 1 for 17 "modern" analyses.

The points representing chemical formulae are set along two segments: the first one joins the points 1 (corresponding closely to $HCa_2FeAl_2BSi_4O_{16}$) and 7 (corresponding closely to $HCa_2MnAl_2BSi_4O_{16}$); the second one joins point 7 to point 17. The second segment lies on the Ca-Mn side of the triangle; considering the side as being divided into three equal part, only the central part is occupied by points.

If one subsequently considers chemical formulae corresponding to a

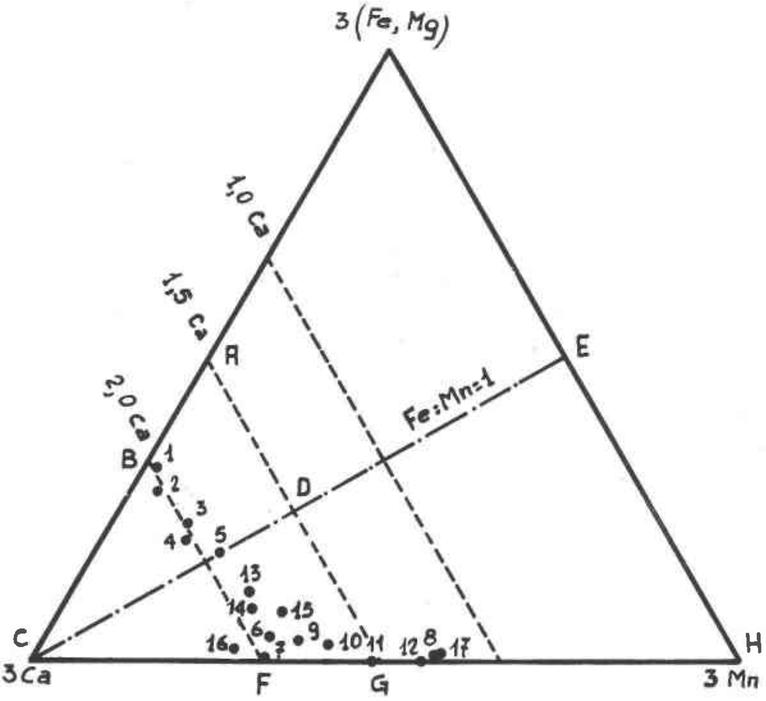

FIG. 1. Distribution of axinites in triangular diagram of pure Ca-, Mn-, (Fe, Mg)-molecules.

The name "ferroaxinite" is proposed for the end-member corresponding to point B and for the axinites falling in the triangle ACD; the name "manganaxite" is proposed for the end-member corresponding to point F and for the axinites falling in the triangle CDG; the name "tinzenite" is proposed for the axinites falling in the quadrilateral EDGH.
Chemical analyses are from:
1. Simonen and Wiik (1952), 2. Howie in Deer, Howie and Zussman (1962), 3. Schaller (1911). 4. Neumann (1944), 5. Soloviev (1956), 6. Fromme (1927), 7. Goldschmidt (1911), 8. Milton, Hildebrand and Sherwood (1953), 9. Palache (1935), 10. Barsanov (1951), 11. and 12. Kayupova (1961), 13. Hoffman and Novak (1966), 14. Getling (1965), 15. French (1966), 16. Penco (1964), 17. Penco and Sanero (1964). Analyses 1 to 8 bear the same number in Deer, Howie and Zussman (1962).

point which, starting from point 1, moves towards point 7 and, after reaching it, towards the lower right vertex, one has a growing content in Mn-ions; in the first part (1 to 7) of the movement, the increase in Mn occurs because of a decrease in Fe-content. When all Fe-ions have been substituted by Mn-ions, each further increase in Mn happens at the expense of Ca. This double diadochy of Mn^{2+} ($R=0, 80$ Å), an easier one with smaller Fe^{2+}-ions ($R=0, 74$ Å) a more difficult one with bigger Ca^{2+}-

ions ($R=0, 99$ Å), is not exclusive of axinite, but is well known (see for example Deer, Howie and Zussman, 1962) for garnets (solid solutions without gap for spessartine-almandine, but with gap for spessartine-grossular), pyroxenes (solid solutions without gap for johannesnite-hedenbergite, with gap for johannsenite-wollastonite), trigonal carbonates (solid solutions without gap for rhodochrosite-siderite, with gap for rhodochrosite-calcite), and other minerals. The gap in solid solutions between manganese-calcium compounds vanishes at high temperature in most cases. Moreover, in the case of axinites, one must remember the complexity of the structure, which favours isomorphism.

NOMENCLATURE

Although no rigid rules have been established so far for the naming of minerals, and a flexible pragmatism has also been preferred by the New Mineral and Mineral Name Commission of IMA, there is a tendency to associate each mineral name with a chemical formula, normally a schematic one, which ignores minor isomorphic replacements. In the case of a solid solution series, two names are accepted for the two pure end-members. For minerals of intermediate composition, the name of the predominant molecule is used.

Our proposal for the axinites are as follows:

1. The name "axinite" must be used as a group name.
2. The name "ferroaxinite" must be used for the end member $HCa_2FeAl_2BSi_4O_{16}$ and for those axinites with $Ca>1.5$ and $Fe>Mn$. Please note that no axinite with $Ca<1.5$ and $Fe>Mn$ has been ever found.
3. The name "manganaxinite" must be used for the end member $HCa_2MnAl_2BSi_4O_{16}$ and for those axinites with $Ca>1.5$ and $Mn>Fe$.
4. The name "tinzenite" must be used for those axinites with $Ca<1.5$ and $Mn>Fe$ (but usually $Mn\gg Fe$).

At this stage it is impossible to say whether tinzenite is an independent mineralogical species or only a variety. This alternative corresponds to the two possible ways of distributing Mn-ions in crystals like 8, 12, 17: if Mn is gathered in one of the Ca-positions of the structure, tinzenite is a species with formula $HCaMn_2Al_2BSi_4O_{16}$; if Mn is regularly distributed in both Ca-positions, tinzenite is a "hypermanganese" variety of manganaxinite $H(Ca,Mn)_2MnAl_2BSi_4O_{16}$ with $Ca>Mn$. But whatever the right hypothesis may be, there is a need for a name to designate minerals like 8, 12, 17.

Chemical modifiers can be used easily for the series ferroaxinite-manganaxinite, so no. 4 can be called a manganoan ferroaxinite, no. 13 ferrous manganaxinite; they can hardly be used for no. 8 (the modifier manganous cannot be used, since the end member $HCa_2MnAl_2BSi_4O_{16}$

contains Mn even in its purest form; the modifiers hypermanganese would be quite correct, and horrible). Recently other names have been proposed for axinites: "severginite" by Barsanov (1951) for mineral no. 10, and "mangansevergnite" by Kurshakova (1967) for mineral no. 8 and 17.

Now, no reason can be invoked to overcome the priority of "manganaxinite" over "severginite"; nor can rule *d* of Dana (1892) be invoked to overcome the priority of "tinzenite" over "manganseverginite", as the original description of "tinzenite" was far from being "so incorrect that a recognition of the mineral by means of it is impossible." Finally we do not propose any name of axinites of composition like $HCa_3Al_3BSi_4O_{16}$, or $HFe_3Al_2BSi_4O_{16}$, which have not been found in nature and, in our opinion, will neither be found nor synthetized.

This work is part of the research programme of the Centro Nazionale di Cristallografia del C.N.R., Roma.

Thanks are due to Michael Fleischer for some useful suggestions and for calling our attention to some new papers on the subject.

References

Barsanov, G. P. (1951) The isomorphous series of axinite, and the new mineral species severginite. *Trudy Mineral. Muz. Akad. Nauk. SSSR., no.* **3,** 10–18.

Dana, E. S. (1892) *The system of Mineralogy of J. D. Dana, Sixth Edition,* John Wiley & Sons, New York.

——— and W. E. Ford (1914) *Second appendix to 6th. ed. of Dana's System of Mineralogy,* John Wiley & Sons, New York 11.

Deer, W. A., R. A. Howie, and J. Zussman (1962) *Rock forming minerals,* Longmans, London, 320.

French, B. M. (1966) Short-range chemical variation in a manganoan axinite from the Mesabi Range, Minnesota. *Amer. Mineral.,* **51,** 1561.

Fromme, J. (1909) XV. Chemisch-mineralogische Notizen aus dem Radautale. *Tschermaks Mineral. Petrogr. Mitt.* [2], **28,** 306–328.

——— (1927) *Die Minerale des Brockengebirges insonderheit des Radautales.* E. Appelhans u. Komp. (Rud. Stolle u. Gust. Roselieb), Braunschweig.

Getling, R. V. (1965) Axinite from the Kyzyl-Espe Deposit. *Zap. Vses. Mineral. Obshch.,* **94,** 607–612.

Goldschmidt, V. M. (1911) Die Kontaktmetamorphose in Kristianiagebiet. *Skr. Norske Vidensk. Akad. I. Mat. Naturv. Kz.* no. 1.

Hey, M. (1962) *An index mineral species and varieties arranged chemically.* British Museum, London.

Hoffman, V., and F. Novak (1966) Axinite and barium-adularia from Chvaletice in the Zelezné Hory. *Sborn. Narod. Muzea Praze, 22B,* 27–46.

Ito, T., and Y. Takeuchi (1952) The crystal structure of axinite. *Acta Crystallogr.,* **5,** 202–208.

Jakob, J. (1923) Vier Mangansilikate aus dem Val d'Err (Kt.Graubünden). *Schweiz. Mineral. Petrogr. Mitt.,* **3,** 227–237.

Kayupova, M. M. (1961) Manganese silicates from the Dzhumart and Kamys deposits in Central Kazakhstan. *Izvest. Akad. Nauk Kazakh. SSSR Ser. Geol.,* no. 2, 45–69.

KURSHAKOVA, L. D. (1967) Isomorphism in the axinite group. *Geol. Geofiz., Akad. Nauk SSSR. Sibirsk. Otdel.*, no. 1, 118–123.

MILTON, C., F. A. HILDEBRAND, AND A. M. SHERWOOD (1953) The identity of tinzenite with manganoan axinite. *Amer. Mineral.*, **38,** 1148–1158.

NEUMANN, H. (1944) Silver deposits at Kongsberg. *Norges Geol. Undersok*, **162.**

PALACHE, C. (1935) The minerals of Franklin and Sterling Hill, Sussex County, New Jersey. *U.S. Geol. Survey. Prof. Pap.*, **180,** 99–100.

PENCO, A. M. (1964) Ricerche cristallografiche, ottiche e chimiche sulla axinite di Monte Pu (Liguria). *Doriana,* **4,** 152.

——— AND E. SANERO (1954) Nuove ricerche sulla Tinzenite di Cassagna (Liguria) e sue analogie con l'axinite. *Doriana,* **4,** 154.

SCHALLER, W. T. (1911) Mineralogical notes, Series I, Axinite from California. *U.S. Geol. Surv. Bull.*, **490,** 37.

SIMONEN, A., AND H. B. WIIK (1952) The axinites from Jokioinen and Petsamo. *C.R. Soc. Géol. Finlande,* **25.**

SOLOVIEV, YU. S. (1956) Axinite from certain deposits of Central Kazakhsta *Zap. Vses. Mineral. Obshch.* **85,** 429.

THE AMERICAN MINERALOGIST, VOL. 53, JULY–AUGUST, 1968

THE PROPORTIONALITY OF QUARTZ IN MYRMEKITE

EVAN R. PHILLIPS, *Department of Geology and Geophysics, University of Sydney, Sydney* AND D. M. RANSOM, *Department of Geophysics and Geochemistry, Australian National University Canberra, Australia.*

A recent note by Hubbard (1967) has again stressed the connection between the composition of plagioclase in myrmekite and the amount of associated quartz. Despite the fact that this proportionality relationship was recorded by Becke (1908) very little quantitative data can be found in the literature, due, no doubt, to the scarcity of relatively coarse intergrowths and the technical difficulties inhibiting accurate measurement. By contrast the absence of quartz in pure albite of the rim and intergranular types is well substantiated.

Gneisses from Broken Hill, New South Wales, contain myrmekites in which the quartz-plagioclase intergrowths are relatively coarse: the quartz stems range roughly from 0.1 to 0.3 mm in length and are 0.01 to 0.02 mm wide. Further, the plagioclase is relatively calcic providing an opportunity for investigation in an uncommon composition range. The results of some detailed measurements for two major rock types are given here.

Quartz and plagioclase volumes were calculated from photomicrograph enlargements (×500) of about twenty-five intergrowths from each rock. The photographs were gridded with one or two inch squares and ran-