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EDITORIAL

PLUGGING POLICY AND PROCEDURES

As everyone knows, the *Record* frequently plugs dealers and their merchandise in columns such as *What's New in Minerals?,* Bob Sullivan's *Letter from Europe,* the *Record Bookshelf,* the *Microminerals* column, and even here in *Notes from the Editor.* For the sake of clarity, it has been suggested that I should spell out our *Plugging Policy and Procedures,* which I am happy to do.

The first criterion is that the information given must be of interest or of value to the readers. A find of three specimens of something, for example, is not as significant as a find of 100 specimens, because fewer readers will be able to acquire examples. Of course, the higher the quality-rarity-desirability of the material, the fewer specimens are required to justify a report. In an extreme case, such as David Wilber's extremely large phosphophyllite, a single specimen justifies the report.

That covers the specimen material . . . what about the dealer getting the plug? This is simply a matter of the information that we (all of us who write for the *Record*) have at hand. If three dealers get lots of a certain discovery, and one of them contacts the *Record* and provides information and/or photos, or specimens on loan for us to photograph, how are we to know about the other two? Whereas we discriminate on what material will be reported, once it is chosen we would be happy to list a number of dealers carrying it.

Some people may wonder whether a "donation" is required to obtain a plug. This is certainly not true. Specimens sent for photography will be returned. Only in the case of books and magazines for review do we require the traditional complimentary review copy. This copy is kept by the person writing the review.

Occasionally the charge of favoritism arises, because people see the names of certain dealers plugged repeatedly. There are reasons for this in addition to their willingness to keep us informed. The most significant reason is that some dealers happen to be at the forefront of the business. They work harder, get luckier, and acquire more new discoveries than some other dealers . . . luck can be a major factor in dealing, but when certain dealers repeatedly get there first on new finds, one must conclude that they're doing something better. In any case, our coverage follows distribution, and the distribution of fine, new minerals among dealers is not even.

Another factor is that some dealers, by choice, do not pursue new discoveries. For example, several East and West Coast dealers concentrate heavily on buying and reselling old collections; so they get less "new" material, and more one-of-a-kind old-timer specimens which, individually, are not "news." Readers should understand that this is the reason why their names appear less frequently than their status would seem to merit.

There is no requirement that dealers plugged be advertisers in the *Record;* such a requirement would conflict with our first criterion, the benefit of the reader. In fact, in cases where the dealer is not an advertiser we commonly give his address or city so that readers may track him down.

I wish it went without saying but apparently it doesn't; so I'll say it. Dealers plugged need not be personal friends of *Record* staff members. In fact, strangers and new-comers are particularly encouraged to contact us about mineral news because our readers will appreciate learning about new sources.

Despite these policies, there are unavoidably arbitrary factors involved. Sometimes there is simply not enough space to publish all of the information we have. Other times we haven't enough information to merit a column, so the little which we do have is shelved. Some minerals are only of very local interest, and go unreported in deference to our nationwide and international readership.

Even though reporters writing in the *Record* endeavor to be objective, their own personal likes and dislikes do enter into their choices of what to write about. This is not necessarily bad. Readers who are unsure of their own taste, and who are trying to develop it more fully, will be interested to know what pleases the taste of well-known writers. In deciding what *not* to discuss, the writer unavoidably becomes a critic. But, because in most cases only the "good" material is covered, the reader has no way of knowing which items the writer weighed and found wanting, and which ones he simply didn't see.

We recognize that market news and reports on new discoveries are perhaps the most important items in the entire magazine for some readers. After all, even professional research first requires the *acquisition* of samples . . . and in collecting, acquisition is the indispensable aspect. Everything follows from that, unless you are content only to admire the collections of others. Interest and private study are always stimulated by the physical object itself. Consequently we will continue to provide the best reportage we can. Criticism of our coverage, however, would be more constructively aimed at who and what we are missing rather than who is receiving too much.

Dealers wishing to submit mineral news for publication should attempt to answer as many as possible of the following questions . . . these are the things readers want to know:

(1) How much material is available?
(2) What is the average quality, and the very best quality?
(3) What do the best specimens look like? (Photos are best here; if the dealer cannot supply photos he may send specimens by registered mail directly to the *Record* where, at the discretion of the editor, they will be photographed and measured. All such specimens will be returned.)
(4) What is the *exact* locality? (Is the information reliable?)
(5) When was the material collected?
(6) What are the determinable chances for the collecting of more material?
(7) How does the material compare to previous discoveries?
(8) What is the retail price range?
(9) Are there any interesting stories associated with the collecting or acquiring of this material?
(10) If some of the top specimens have already been sold, where might the public go to see them?
(11) Does the material have any interesting mineralogical features or aspects?
(12) What are the details describing the geological and mineralogical environment of the mineral's occurrence?
(13) What are the associated species, and how were all of the species identified?

There are some types of information which we will not publish. The *Record* has no free listing of coming shows (though paid ads are always welcome) . . . these are admirably covered by other magazines. The only exception to this rule is Bob Sullivan's column, which commonly gives the dates of European shows not listed in American publications. The *Record* does not publish "press releases" having to do with personnel changes in the mineral business, shop openings, awards presented, or coming seminars and short courses. We avoid handicrafts, rocks (including tektites), and fossils, and make only the rarest reference to cut or polished minerals. Of course we reserve the right to break our own rules in special cases, but those cases will be very rare.

Show reports should not be considered as a form of recognition or award to exhibitors mentioned. Displays which happened to catch the writer's eye will be discussed, without rigorous regard to the individual merits of all other displays, the prestige of the displaying individuals or institutions, or the distance which exhibitors had to travel. An unmentioned exhibit is not being purposely overlooked or judged inferior. Consequently, no exhibitor should feel he has somehow earned the right to be mentioned in the *Record*. The discussion of temporary exhibits which can no longer be seen is of far less importance to readers than the discussion of still-purchaseable minerals, so the former will not be given comprehensive coverage.

Our goal is simply to make the best use of our limited space for the mineral collector and specimen-oriented mineralogist. If this happens also to benefit some dealers (and many of our readers *are* dealers), then we are happy for them. But benefiting dealers is not specifically one of our goals . . . that is what distinguishes the *Record* from a "trade journal." We do feel that a healthy and active mineral market is in the best interest of everyone, and we are pleased by whatever side-effects the *Record* produces in this regard.

notes from the EDITOR

ARIZONA I AND II SOLD OUT

Amazingly, both Arizona-I and Arizona-II (our May-June and July-August 1980 issues) were sold out before the following issue was even mailed. Some people are sure to ask, "Why didn't you have more printed?" The answer is, because sales are so difficult to predict. For example, we still have quite a few copies left of our 104-page color California issue (November-December 1977) and our color Colorado-II issue (November-December 1979). We thought the 9500 copies of the Arizona issues would last us several months to a year, but they didn't. Now it would be too expensive to go back to press for just two or three thousand additional copies (and we can guarantee that we never will reprint them). My congratulations to the people who were prompt enough to get their extra copies ordered in time. At a recent mineral show I saw copies selling for $6 each already, so it appears that these two issues have already achieved the status of collector's items.

NEW FILM AVAILABLE

The Gemological Institute of America (1660 Stewart Street, Santa Monica, California 90404) has recently made available a new 30-minute film entitled *Gems of the Americas.* D. Vince Manson of G.I.A. and Peter Keller, curator at the Los Angeles County Museum of Natural History, were instrumental in its production (Keller is now employed by the G.I.A.). The movie covers several gem species and localities, including the Colombian emerald fields, in an entertaining and interesting way. The approach is almost totally non-technical; particularly sophisticated audiences may chuckle at the sight of a perfectly clean crystal of aquamarine being extracted from a muddy pegmatite pocket by a Brazilian miner. Such little bits of staging are necessary to tell the stories, however, and constitute perfectly acceptable use of artistic license. Members of the Tucson Gem and Mineral Society who previewed the movie with me all found it to be enjoyable and excellently made. The overall production quality is first class, and the narration of actor Richard Basehart (of the old *Voyage to the Bottom of the Sea* television series) provides an additional professional touch. The film may be purchased or rented. I'd like to see more gem and mineral shows rent films of this caliber and show them semi-continuously throughout the show, as an alternative to an additional speaker on their program.

ANOTHER CALENDAR FOR 1981

Calendar fans and (are there any?) collectors will be pleased to learn of another new calendar of minerals available for 1981. The cover photo shows "The Snail" rhodochrosite specimen (N'Chwaning mine, South Africa) belonging to Pala Properties. All of the color photos are minerals, but the back cover shows a black and white photo of a group of 12 antique miners' lamps. The calendar may be ordered for $5.95 from Holohedral Productions, P.O. Box 5506, Tucson, Arizona 85703 (from whom wholesale discounts are also available), or may be purchased through various mineral dealers.

MINE LAMP COLLECTORS UNITE!

For some reason, it's unusually difficult for miners' lamp collectors to learn of each other. In part this is probably because there are only a few hundred collectors at most in the United States, and they are not liable to bump into each other by accident. Many are reluctant to share acquaintances for fear of losing good trading partners to other, more voracious, traders . . . a short-sighted attitude.

Happily, something is now being done to remedy the situation. Ken and Betty Roberts (P.O. Box 1267, Twain Harte, CA 95383) are compiling a list of miners' lamp and mining memorabilia collectors, which they will circulate to anyone for the asking. They may eventually begin putting out a monthly trading newsletter. Anyone, beginner or long-time collector, who is interested in miners' lamps, antique mining equipment, mining stock certificates, gold scales, scrip, old mining photographs, ore cars (yes, some people do collect ore cars), dynamite boxes, blasting cap tins, miners hats, canary cages, mining equipment catalogs, and anything else along these lines is invited to drop the Roberts a line mentioning their specialties and trading or purchasing interests.

I would imagine that, from time to time, collections and small lots will come up for sale. Naturally they will be advertised to people on the Roberts list, so sending in your name may help you with purchases. The only requirement is that you must allow your own name to be circulated to the other people on the list. So get going and write; the service is free.

famous mineral localities:

zeolites from Iceland and the Faeroes

by **Volker Betz**
Talstrasse 13
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West Germany

Erasmus Bartholinus first wrote about Icelandic minerals in 1669, and since that time they have been studied and written on by every generation of mineralogists. Iceland and the Faeroes have produced huge amounts of fine zeolites of many species, and still produce them today, though modern collectors are liable to find the specific locality names unfamiliar and forbidding to pronounce.

Figure 1. **An atypically sunny day near Helgustaδanáma, Iceland; Hólmatindur (Holma Peak) near Reyδarfjörδur is in the distance.**

INTRODUCTION

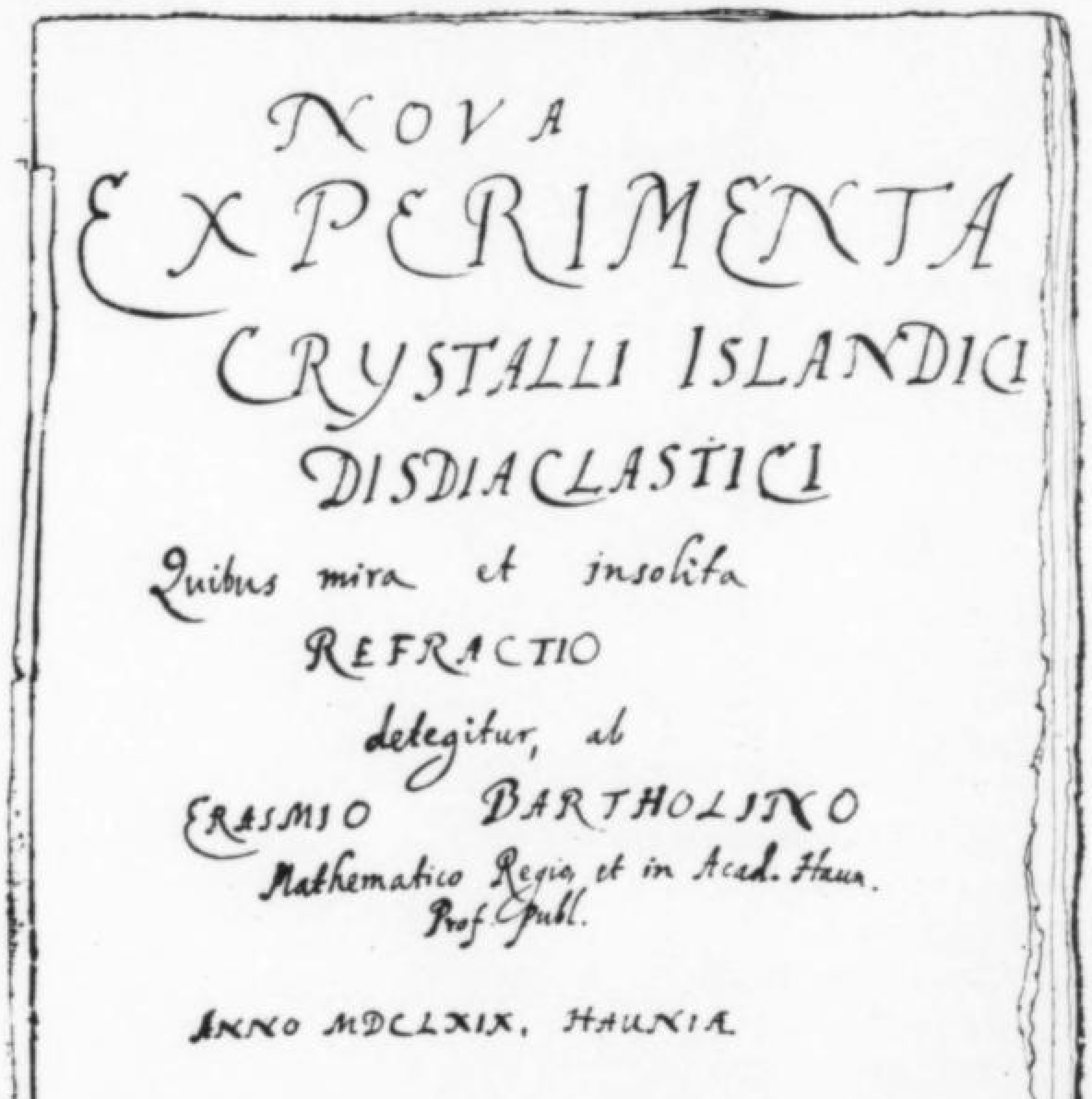
In the region of the North Atlantic, vast areas of the land and sea floor are covered by basalts which constitute the North Atlantic (or Thulian) Tertiary Igneous Province. These basalts, visible in eastern and western Greenland, Iceland, Jan Mayen, the Faeroes, Scotland and northern Ireland, are famous among most mineralogists and collectors for the fine specimens of zeolite minerals which occur there. Iceland and the Faeroes have been particularly productive, and fine examples may be seen in most of the older European museums. The best collection is probably that of the Geological Museum in Copenhagen, Denmark; this is not surprising in view of the fact that Iceland belonged to Denmark until becoming an independent republic in 1944, and the Faeroes still belong to Denmark, though they have been granted extensive home rule.

Considering that the first reports on Iceland and Faeroes zeolites are over 300 years old, the islands might well be called the classic occurrences for this group of minerals. In addition to some historical aspects, this paper describes the present situation at the various localities, and the minerals which occur there.

HISTORY

During a walk over the Icelandic plateau basalts, one will occasionally see white stones amid the rocky ground. A moment's inspection shows these to be quartz or zeolite minerals. The early inhabitants of Iceland no doubt made the same observations; pagan burial sites have been found to contain items of quartz, chalcedony and zeolites apparently placed there for their magical value (Steffensen, 1967).

The earliest scientific paper on Icelandic minerals happens also to be one of the milestones of the natural sciences: *Nova experimenta crystalli Islandici disdiaclastici,* published by Erasmus Bartholinus in 1669. His discovery and detailed description of the birefringence (double refraction) of "Iceland spar" calcite is on file in its original manuscript form at the Kongelege Bibliotek in Copenhagen. (A German translation was published by Mieleitner in 1922.)



NOVA
EXPERIMENTA
CRYSTALLI ISLANDICI
DISDIACLASTICI
Quibus mira et insolita
REFRACTIO
detegitur, ab
ERASMIO BARTHOLINO
Mathematico Regio, et in Acad. Haun.
Prof. Publ.

ANNO MDCLXIX, HAUNIA

Figure 2. **The title page from the original handwritten manuscript of the classic work on the double refraction of "Iceland spar" calcite, by Erasmus Bartholinus. It reads: "New experiments with birefringent Icelandic crystal, leading to the discovery of a miraculous and extraordinary refraction, by Erasmus Bartholinus, Royal Mathematician and Professor at Copenhagen University, Anno 1669, Copenhagen." Photocopied from the manuscript in the Kongelege Bibliothek, Copenhagen.**

Currie (1907) says that "a few of the minerals of Faeroe are mentioned vaguely by L. J. Debes in 1673" (though the present author has been unable to locate a copy), and zeolites from Iceland are mentioned by Horrebow (1752). Horrebow makes note of "crystallus Islandicus" (Iceland spar) and other types of crystals occurring in the cliffs.

Some interesting details are given in a letter from Olaus Olavius (also known as Olafr Olafson, 1741–1788) to Theodor Holm (or Holmskjold, 1731–1795). (Holm's mineral collection, incidentally, was valued at 25,000 Reichstaler in 1787.) The original letter, in Danish, is kept in the Archives of the Geological Museum, Copenhagen. It reads (in translation) as follows:

> To the Honorable Conferenzrat Holm
> Most humble Pro Memoria!
>
> I deem it an honor to thank you for your communication as well as all other favors shown to me. As far as the specimens of minerals are concerned, the big quartz stone was taken from the top of the Helgestadskarð[1] or, to be more exact, from the slopes of the Skarðveg facing the Nordfjord[2]; the white kind of lava, too, was taken from the very top of the Helgestadskarð and so was the green jasper. However, the fossil was found on the other side of the trail which leads to the Rödefjord[3] and the Doppelspat[4] just before the Helgestad[5] farm. The piece of ore[6] was found near Hammersfjord[7] and so was the concretion and the chalcedony, but the zeolite was found at the Rödefjord and in the Breidtal[8] as well as at the Berefjord[9]. The largest piece of chalcedony was found on the way between the Rödefjord and the Fascradsfjord[10], and it is certain that there are still quite (large) quantities left of all of them. If you desire any further information I shall be pleased to supply you with more details. Meanwhile, I remain
>
> your most humble servant
> Olaus Olavius
> Copenhagen, April 30, 1777.

On April 11, 1777, just a few weeks before Olavius wrote his letter to Holm, J. D. Cappel gave a lecture on a very attractive chalcedony specimen over 20 cm in size; the lecture was subsequently published, with figures, in 1781. Some years later, in a lecture on October 26, 1792, C. F. Schumacher described a "crystal-bearing hair-zeolite" from the Faeroes. Judging by his description, this must have been a specimen of acicular mesolite with apophyllite crystals perched on the mesolite hairs to form a spectacular piece.

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[1] Today called Oddskarð.
[2] Today called Norðfjörður.
[3] Today called Reydarfjörður.
[4] Doppelspat = double spar = Iceland spar calcite.
[5] Today called Helgustaðir.
[6] Possibly chalcopyrite from Svínhólar, Lónsheiði.
[7] Today called Hamarsfjorður.
[8] Today called Breiðdalur.
[9] Today called Berufjörður.
[10] Today called Faskruðsfjörður.

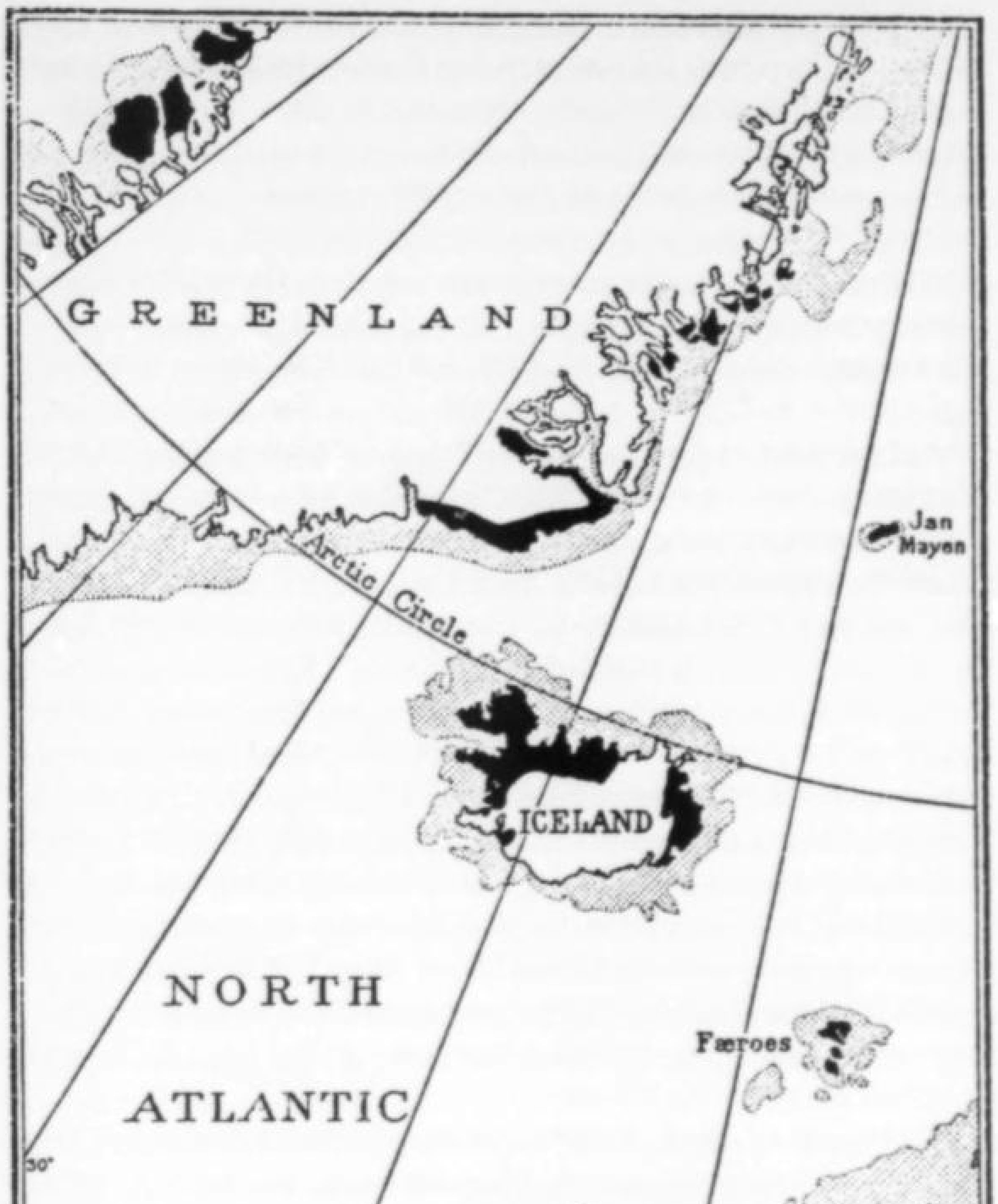

Figure 3. **Map of the North Atlantic (or Thulean) Tertiary igneous province (from Richey, 1961, p. 42).**

In 1801, Schumacher listed the following zeolites as occurring in Iceland and the Faeroes (details on localities were not given): mehliger (floury) zeolite, körniger (granular) zeolite, dichter (compact) zeolite, fasriger (fibrous) zeolite, strahliger (radiating) zeolite, strahlig-blättriger (radiating-leafy) zeolite and blättriger (leafy or lamellar) zeolite.

Sir George S. Mackenzie visited western Iceland in the summer of 1810, and presented a collection of Icelandic rocks and minerals to the Royal Society in Edinburg. In his book (Mackenzie, 1815) he lists chalcedony and zeolites from Hval-fjord (Hvalfjörður) near Houls (Háls), and chabazite from the shore near Indre-Holm (Innriholmur). He also made note of zeolites and chalcedony, though not remarkably fine, at Skardsheide (Skardsheiði), and collected a fine specimen of stilbite north of Stadarrhaun (Staðarhraun). Mackenzie was accompanied on his travels by Thomas Allan who, in 1815, published a description of various mineral localities on the Faeroe Islands which they visited during a stopover on the way to Iceland.

Like Mackenzie and Allan, most visitors to Iceland have failed to visit the eastern fjords because they would have had to cross on horseback either the desert of central Iceland or the dangerous glacial rivers at Vatnajökull. We are more fortunate today; the last river at Vatnajökull, the Skeiðará, was bridged in 1974.

Despite the inherent difficulties, Ebenezer Henderson traveled around Iceland in 1814 and 1815, "exclusively to investigate the wants of its inhabitants with respect to the Holy Scriptures." His eyes were not closed to the nature around him, however, and he gives us the following description of Teigarhorn, "the place of stones" at Berufjörður, from his visit on September 1, 1814:

> The following day, after having written a letter to Mr. Stephensen, explanatory of the mode in which I wished the copies of the Scriptures that had arrived at this harbour to be disposed of, as my horses had not yet come round the bay, I made a short excursion along the southern shore of the *Berufiord,* accompanied by Jonathan, Mr. Stephensen's assistant, who is a native of the West Indies, and has spent several years at this place. At the distance of about three miles from the factory, we came to a long irregular range of cliffs, where "the shore, eat into caverns by the restless wave," exposed "the place of stones," and disclosed to the ravished eye some of the most unparalleled beauties of the mineral kingdom. In the hard rock were numerous and widely diversified crystallizations of quartz; but what particularly attracted my attention, was the zeolite, or star-stone, so called from the beautiful shining rays of crystal, which all diverge from a common centre, and terminate in a pyramidal form. It was imbedded in argillaceous earth, and on this account is easily dug out; but was so exceedingly brittle of itself, that it could hardly bear the removal of the clay. Of this mineral I met with many beautiful varieties. Some of these stars contain four-sided rays, or bars, of crystal, nearly as fine as hairs, and not more than a quarter of an inch from the centre to the circumference: others consist of bars, near a quarter of an inch in thickness, and three or four inches in length; while others are found in the shape of a goose's egg, but twice as large, which, on being broken, present a flat surface, consisting, at the one end, of a white, and white-bluish substance, resembling cornelian, and, at the other, of beautiful bars of white crystal, that lie close together, like pillars in a bed of basalt. These last are covered with a thin coat, of a light green colour, in which, in various places, small prominences appear, consisting of a greenish loose-grained substance. At the same place I found some small light stones, externally of the same colour, but, on being broken, they discovered a beautiful shining substance,

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Linguistic notes:

The letter ð *(eth)* is an old Germanic letter pronounced as a soft *th,* as in "wi*th*in."

The following suffixes on locality names indicate geomorphological features:

á = river
dalur = valley
ey, oy = island
fell = mountain
fjall, fjöll = mountain(s)
fjörður, fjørður = fjord or valley
foss = waterfall
heiði = heath or moor
jökull = glacier
skarð = pass
staður = place or site
tindur = mountain peak
vatn = lake

Considering that *oy* means *island,* it is redundant to write *Sandoy Island,* however, the word *island* is used here for the sake of clarity.

The Faeroe Islands are commonly referred to as the Faeroes because, in the original spelling *Føroyar,* the *oyar* (equivalent to the *oe*) means *Islands.* Strictly speaking, *Faeroe Islands* is therefore somewhat redundant, though it is an accepted useage for the sake of clarity.

> which I take to be calcarcous spar. Chalcedonies and red jasper also abound in the neighbourhood; and, though most of the European cabinets have been stocked with specimens from this place, in the selection of which the greatest waste has been made, it still contains inexhaustible treasures, and would richly repay the toils of the naturalist who spent a summer here in mineralogical researches.
>
> As I surveyed this museum of natural curiosities, and reflected that little more than half a century has elapsed since the zeolite attracted the attention of naturalists, when they were sadly puzzled in endeavouring to account for its formation, I could not but adore Him whose all-skilful hand has given to the particles of matter the admirable order and regularity displayed in the composition of the minerals before me—whose workmanship infinitely transcends the proudest efforts of human genius, and baffles the most profound researches of inquisitive man.

Among the first chemical analyses of "ächtem Desmin" from Iceland and the Faeroes are those published by Hisinger in 1818, though others were done around that time. Levyne was described as a new species from Dalsnypen (Dalsnípa), Sandö (Sandoy), in the Faeroes, by Brewster in 1825. Epistilbite was described as a new species from Iceland by Rose in 1826. Additional reports on Icelandic zeolites were published by Sartorius von Waltershausen in 1853.

Rammelsberg (1860) listed a number of species from Iceland and the Faeroes (see Table 1), and gave 46 analyses, over one-third of all the analyses cited for those species worldwide up to that time . . . this gives some suggestion of the importance of the Iceland and Faeroes occurrences to 19th century mineralogists.

Table 1. **Icelandic and Faeroes zeolites listed by Rammelsberg (1860).**

Mineral Species	Number of Analyses Given Iceland	 Faeroes
Thomsonite	1	1
Färölith (Thomsonite)	0	1
Mesotyp (Natrolite)	1	0
Scolecite	4	2
Mesolite	4	3
Levyne	1	2
Phillipsite	1	0
Chabazite	0	2
Parastilbite (Epistilbite)	1	0
Epistilbite	7	0
Stilbite (Heulandite)	3	1
Desmin (Stilbite)	4	7

In 1860, the same year in which the Rammelsberg paper was published, Zirkel listed the following principal mineral occurrences in Iceland:

1. Hvalfjörður
2. Area between Siðmúli and Norðtunga, the "Kallsfell" Mountain between Norðtunga and Baula
3. Area around Hvammur in the Norðurá Valley
4. Dýrafjörður
6. Tindastóll and Skagafjörður Mountains
6. Rock walls in front of Akureyri
7. Djupivogur in eastern Iceland
8. Bulandstindur in eastern Iceland
9. Eskifjörður in eastern Iceland
10. Berufjörður in eastern Iceland

Descloizeaux (1862) reported occurrences of levyne from Midivaag (Miðvágur) on Waagö (Vágar) in the Faeroes, Önundafjord (Önundarfjörður), Dyrefjord (Dýrafjörður), and several other localities in Iceland.

Judging from specimen labels in museums, it seems that most collecting in Iceland took place during the last third of the 19th century. A large number of labels in the Geological Museum, Copenhagen, are dated during that period, but many are undated as well and are probably older. Johnstrup (1877) reported on a collection of 395 (!) specimens of epistilbite from the east side of Øfjord (the old Danish name for Akureyri), and mentioned a Miss Weywadt (her name appears frequently on labels) residing in Djupivogur, a few km from Teigarhorn, who collected for the museum in Copenhagen.

Mineral collecting in the Faeroe Islands took place throughout the 19th century, but the most detailed locality reference is Currie (1907); he visited the islands in 1902 and again in 1905 on the yacht *Ellida.* In a 68-page article he describes over 100 localities (!) . . . information which is still useful today. Many historical data and a list of 51 references are included.

Sixty-six Faeroes localities, many different from those described by Currie, are detailed by Görgey (1910), who visited the Faeroes in the summer of 1907, accompanied by F. Cornu. It is surprising that, considering the volume of information published on Faeroes localities by Currie and Görgey (cited above), there has been so little mineral collecting since that time. But traveling to (and on) the Faeroes was more difficult before World War II, and the weather is typically terrible. Currie (1907) characterized the Faeroes as "buffeted by storms, and shrouded for most of the year by rain or mist."

There has been relatively little collecting on Iceland as well during the first part of this century. But Iceland was rather isolated before World War II, and traveling was expensive. Reck (1912) indicated daily expenses of 25 to 33 Deutsch marks for a traveler, roughly equal to a week's salary in those days.

Several recent publications are of value. Walker (1960 and 1962) published some very informative papers on the zeolites of eastern Iceland (used by the present author as collecting guides since 1971). Most recently, a paper on Icelandic zeolites (unfortunately *in* Icelandic) was published by Jakobsson (1977); localities and species are listed on a small map. Jakobsson mentions that Nicoline Weywadt (1848–1921), a photographer, and Joni Ludvikssyni (1883–1958), a relative of hers in Teigarhorn, exported zeolite specimens to dealers and collectors in northern Europe, mostly during the years 1893–1914 and 1924–1938.

GEOLOGY

The Tertiary plateau basalts of western, northern and eastern Iceland all contain occurrences of zeolites. A succession of flows totaling 5 or 6 km in thickness comprise the plateau. The flows are numerous indeed; Walker (1959) counted over 550 distinct flows averaging 10 m in thickness at Reydarfjörður. The flows consist of tholeiites (48 percent), olivine basalts (23 percent) and prophyritic basalts (12 percent), alternating randomly. Walker (1960) demonstrated the existence of flat-lying zeolite zones unrelated to lava flow stratigraphy in the Breiðdalur-Berufjörður area.

Walker (1960) described three distinct zeolite zones within the olivine basalts. The lowest zone, from below sea level to about 750 m, is rich in mesolite and scolecite as compact amygdules. Zeolitization has been most intense within this zone, resulting in the largest number of mineral species. Mesolite and scolecite are typically accompanied by chabazite, thomsonite, analcime, stilbite, heulandite, apophyllite, gyrolite, and in some places levyne and laumontite.

Above the mesolite-scolecite zone is the analcime zone, about 150 m in thickness. Mesolite is much less abundant here, and occurs as delicate acicular fibers. Stilbite and heulandite are also less abundant, and chabazite, thomsonite, levyne and phillipsite are more prominent.

Above the analcime zone the olivine basalts contain a restricted assemblage of zeolites, mostly chabazite, thomsonite, levyne, phillipsite and gismondine with some calcite and apophyllite as well. This chabazite zone extends to the mountain tops.

Walker (1960) showed that the mineralization in tholeiites is quite different from that in olivine basalts. Chalcedony, mordenite, chlorophaeite, celadonite and epistilbite are essentially confined to tholeiites, and all but the last are extremely abundant. Stilbite and heulandite are much more common in tholeiite basalts than in olivine basalts. Chabazite and thomsonite are seldom seen in tholeiites, and analcime, phillipsite, levyne, gismondine and gyrolite are almost never found there.

The zeolite zones in tholeiites border each other at altitudes similar to those in the olivine basalts. The lowest zone, reaching a maximum altitude of about 300 m, contains abundant zeolites associated with quartz and chalcedony. "It is in this lowest zone that the magnificent specimens of stilbite, heulandite, scolecite and epistilbite are found," according to Walker (1960).

Zeolites continue to be abundantly present up to an altitude of about 750 m in the tholeiites. Above this is a zone consisting largely of mordenite accompanied by chalcedony and quartz rather erratically distributed. Mineralization diminishes with increasing altitude until, above an ill-defined level, vesicles in tholeiite are empty.

Zeolite zones in geothermal areas of Iceland are described in more detail by Kristmannsdottir and Tomasson (1978).

The Faeroes are composed entirely of Tertiary basalts similar to those of Iceland, and zeolites are known from virtually every island in the group. A modern geology of the Faeroes was published by Rasmussen and Noe-Nygaard in 1970, but no data on zeolites were given. It appears that zeolite zoning is also present in the Faeroes but the assemblages, dominated by chabazite, are remarkably different from those of Iceland.

LOCALITIES IN ICELAND

Hvalfjörður (location 1)

Zeolites from Hvalfjörður have been reported by several authors (Mackenzie, 1815; von Waltershausen, 1853; Schwarzbach and Noll, 1971; and Jakobsson, 1977). The 30-meter-high cliffs on the southern shore near Hvaleyri have yielded analcime, chabazite, heulandite, levyne, mesolite, stilbite and thomsonite. Non-zeolites reported include apophyllite, calcite, chalcedony and jasper. Von Waltershausen noted parastilbite (= epistilbite) from Thyrill, a peninsula at the northeast end of Hvalfjörður. A mordenite specimen from a quarry on the west side of Hvalfjörður may be seen at the Geological Museum, Copenhagen. Specimens from Hvalfjörður are usually unremarkable.

Skorradalur (loc. 2)

Stilbite and mordenite have been found near a road at Hestfjall, Skorradalur. Well developed stilbite crystals to 3 cm occur with mordenite as compact fillings in small cavities.

Hvitarsiða (loc. 3)

Chabazite and stilbite from Husafell, Hvitarsiða, were reported by Schwarzbach and Noll (1971). A number of specimens, some quite fine, of epistilbite, chabazite and quartz at the Geological Museum, Copenhagen, are labeled as coming from Topagata i Tunga, Hvitarsiða. Zeolites have also been mentioned (Zirkel, 1862) as coming from the area between Siðumúli and Norðtunga. During a short visit to that area, the author found some poor specimens of stilbite.

Hvammur (loc. 4)

Zeolites have also been reported (Zirkel, 1862) in the area around Hvammur. Levyne was noted in particular, from Mjöadalsa Canyon near Sanddalstunga, about 6 km north of Hvammur. Cowlesite, lining small cavities up to about 2 cm in size, is present in the same rock. Abundant chabazite has been found, as crystals to 2 cm, in the Nordurá riverbed about 1 km east of Hvammur.

Djúpifjörður (loc. 5)

An occurrence of calcite at Djúpifjörður was described by Thoroddsen (1891), and this occurrence was confirmed during a visit by the author in 1973; stilbite was found in association with calcite. Stilbite is also present in several occurrences along the northern shore of Djúpifjörður, accompanied by heulandite, quartz, jasper and agate. In addition, Jakobsson (1977) reported mordenite from nearby Djúpidalur.

Önundarfjörður and **Dyrafjörður** (loc. 6)

These fjords in northwestern Iceland are known for levyne and thomsonite (Hintze, 1897); specimens are preserved (one with a Descloizeaux label) in the Geological Museum, Copenhagen. Jakobsson (1977) mentions chabazite and levyne from Óslid near Bolungarvik.

Tindastóll (loc. 7)

The Tindastóll Mountains west of Skagafjörður were noted as a zeolite locality by Zirkel (1862). Details of shoreline occurrences at Glerhallavik are given by Lohmeyer (1961). Laumontite was found to be extremely abundant in Hrafná Canyon near a T-junction of the road about 1 km south of Skiðastaðir.

Kotá and **Norðurardalur** (loc. 8)

Phillipsite and chabazite (variety phacolite) are very abundant in Kotá Canyon, near the bridge on road No. 1. Micro crystals of analcime and thomsonite also occur there.

Eyafjörður (loc. 9)

Zeolites occur at several locations in the Eyafjörður. Zirkel (1862) reports the rock walls at Akureyri and Vaðlaheiði as containing levyne. Johnstrup (1877) reported collecting 395 specimens of epistilbite at Ofjord (also written Öfjord and Oefjord), which is an old Danish name for Akureyri. Many specimens labeled Ofjord exist in the collection of the Geological Museum, Copenhagen. The small museum of natural history at Akureyri contains zeolite specimens from Árskogasströd on the western shore of Eyafjörður. Erionite was reported by Jakobsson (1977) from Hofsá, Svarfaðardalur, northwest of Akureyri.

Skagafell (loc. 10)

Some of the many garronite and gismondine localities reported by Walker (1962b) are located near and at Skagafell, northwest of Reydarfjörður. During a visit by the author in 1978, gismondine and levyne were found in abundance at about the 600-m level.

Reydarfjörður (loc. 11)

The Helgustaðanáma mine, famous for its Iceland spar calcite, is located on the northern shore of Reydarfjörður. In addition to calcite, this occurrence has yielded many fine stilbite specimens. Other minerals present include quartz, heulandite and laumontite. The locality has been closed to collecting and protected by law for the last several years.

Zeolites are also known from near Eyri on the southern shore of Reydarfjörður. Walker (1962) and Jakobsson (1977) reported chabazite, garronite, gismondine, levyne and phillipsite from the Skessa and Eyrarfjall Mountains at the southwest head of Reydarfjörður. Chabazite and analcime have been found in a roadcut near Oddskard (and near Svartafjell) along the road from Eskifjörður to Neskaupstaður, north of Reydarfjörður.

Breiðdalsheidi (loc. 12)

The dumps of a roadcut east of Heiðarvatn at Breiðdalsheidi have produced analcime, chabazite, stilbite, thomsonite, apophyllite and calcite.

Stöðvarfjörður (loc. 13)

The large regional collection of Petra Sveinsdottir in Stöðvarfjörður contains many zeolite specimens from nearby locales, but the bulk of the collection consists of quartz varieites and habits including clear, prismatic crystals to 10 cm, jasper, agate, and fine specimens of chalcedony.

Breiðdalur (loc. 14)

Zeolites from Breiðdalur were mentioned in the above-quoted letter of Olavius, and some additional details were given by Walter (1960). Fine stilbite is present along the shore near Ósfjall at Breið-

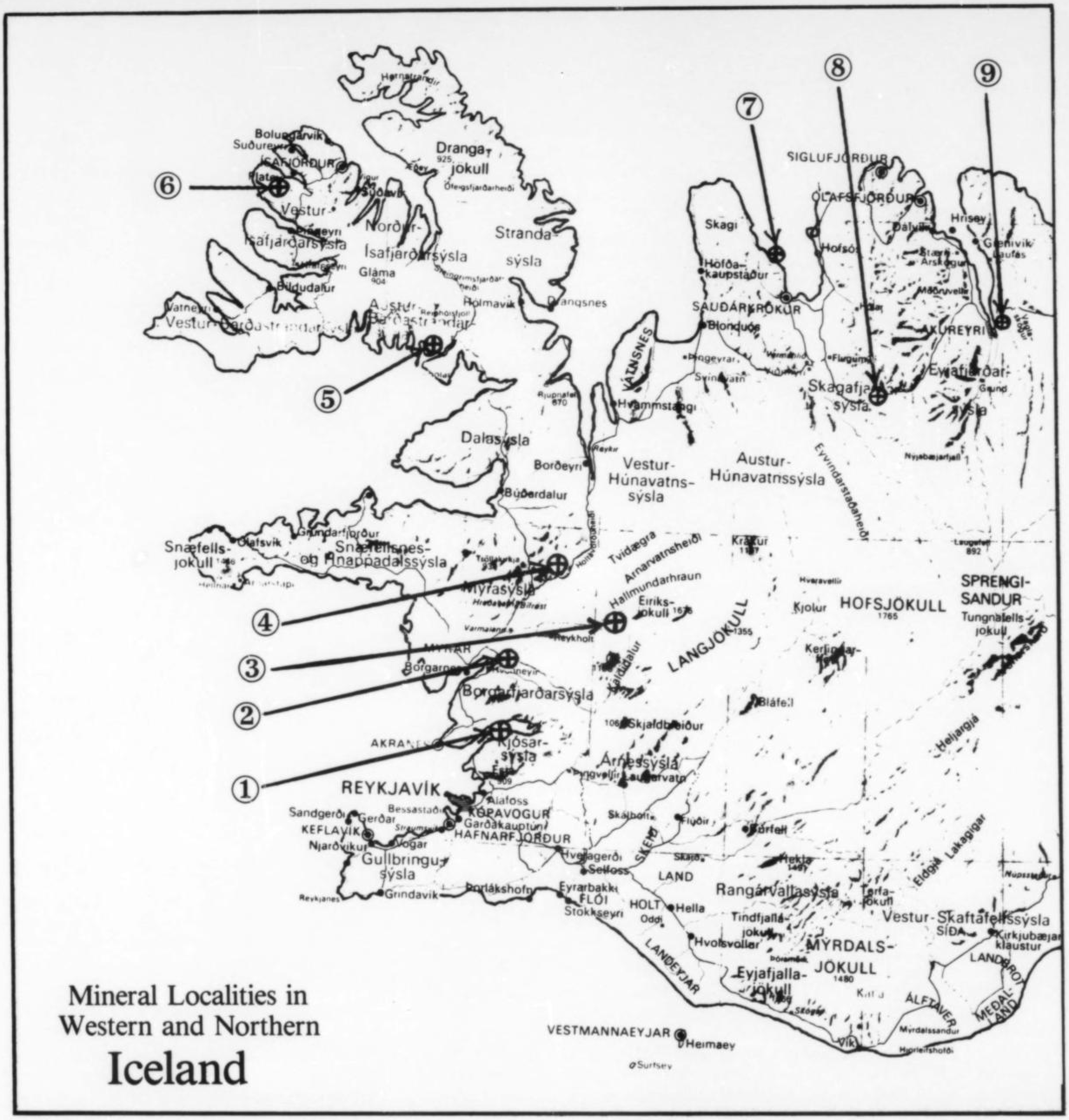

Figure 4. **Mineral localities in western and northern Iceland.**

dalsvik. Boulders of scolecite were collected at Djúpidalur, west of Ósfjall, and mesolite near Naphorn, south of Ósfjall. Several localities reported by Walker (1960) are in the same area. Jakobsson (1977) described epistilbite, garronite, heulandite, mesolite, scolecite and, stilbite from Norðurðalur (not the same as Norðurardalur, loc. 8), the northern branch of Breiðdalur. Children at the Ássunarstaðir farm have sold large amounts of chalcedony, jasper and various zeolites (mainly boulders of scolecite-mesolite) to visitors.

Berufjörður (loc. 15)

Teigarhorn, at Berufjörður, is the most famous zeolite locality in Iceland, and has been producing specimens for over 200 years. A few years ago the locality was closed by law to collecting and visiting.

The zeolites at Teigarhorn occur in tholeiite cliffs near the Teigarhorn farm. The rock there is very rich in cavities reaching over 1 m in size. Zeolites also occur at other localities in the Berufjörður, for example at Fossárfell and Rauðafell in the western end of the fjord, but specimens are not easily found. Locality details are given in Walker (1960); he lists the following species from the Breiðdalur-Berufjörður area: analcime, chabazite, epistilbite, erionite, gismondine, heulandite, laumontite, levyne, mesolite, mordenite, phillipsite, scolecite, stilbite and thomsonite, and also the non-zeolites apophyllite, aragonite, calcite, celadonite, chalcedony, opal, chlorite, epidote, gyrolite, okenite and quartz. Walker (1962a) adds garronite to the list.

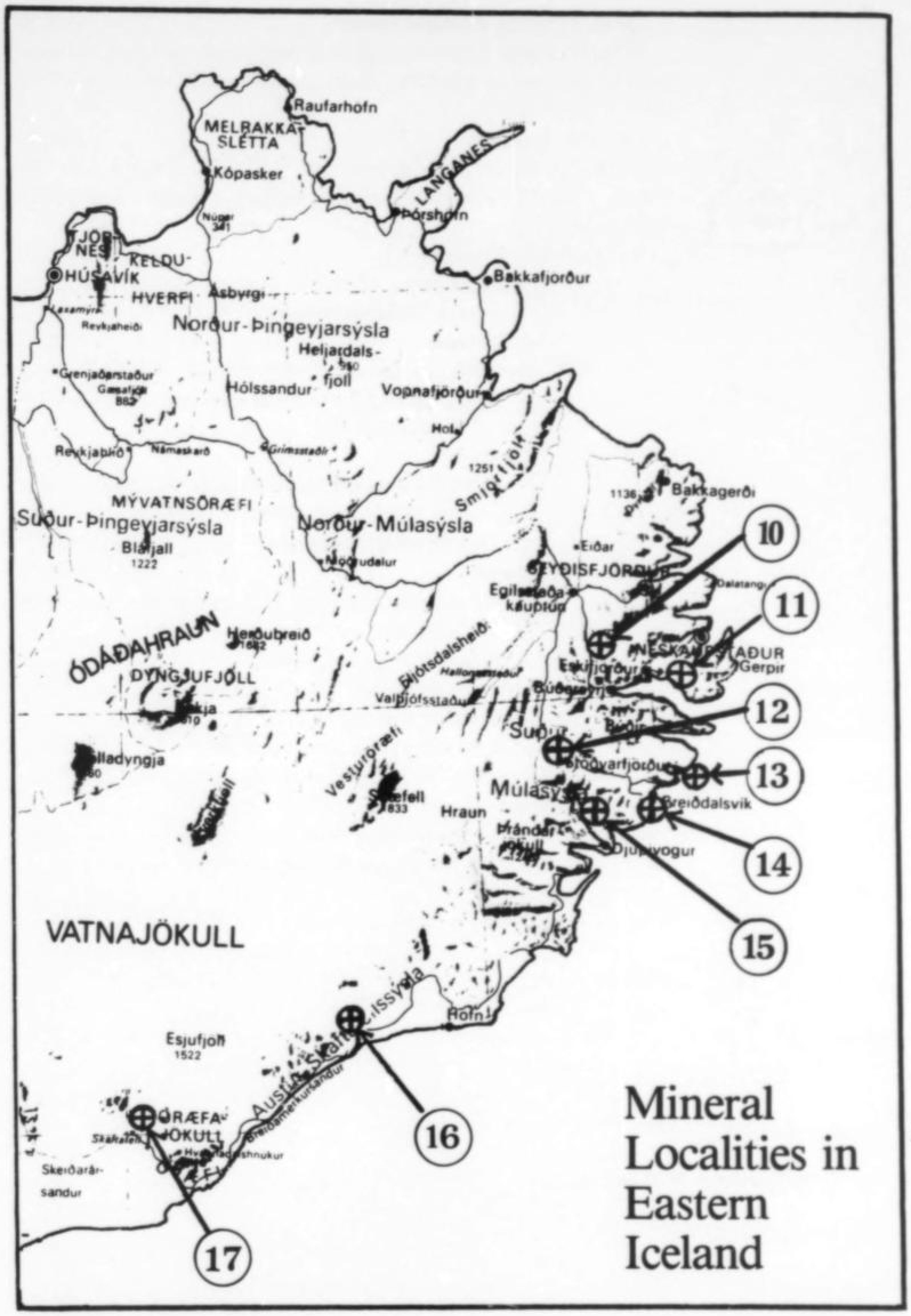

Figure 5. **Mineral localities in eastern Iceland.**

Skálafellshnúta (loc. 16)

Jakobsson (1977) lists yugawaralite from Skálafellshnúta near Heinabergsjökull. This rare zeolite is also known from Dorgeirsfell, Snaefellsnes, in western Iceland. A further locality for calcite, heulandite and scolecite is listed as near Hoffel, about 25 km northeast of Skálafellshnúta.

Hafrafell (loc. 17)

Heulandite, stilbite, laumontite and calcite occur in an abandoned quarry at Hafrafell near Skaftafell, a famous national park of Iceland. This quarry was operated for large boulders which were used for riverbed modification of the nearby Skeiðará River.

LOCALITIES IN THE FAEROES

A large number of Faeroes localities are described in Currie (1907) and Cornu (1907), papers which are still very useful to the collector. Nevertheless, some drastic changes have taken place in the Faeroes since the turn of the century. Formerly no roads save a few footpaths existed, and all traffic took place by boat. A network of roads was constructed following World War II and is still being expanded. Many small quarries were left by the road construction crews, and many portions of the roads were carved into steep slopes by blasting. As a result, the rocks are better exposed in addition to being made more accessible. Most of the localities listed below are a reflection of these recent developments. Topographical names are taken from the new 1:100,000-scale maps and are commonly very different from the names (given in parentheses) in older maps and articles.

Viðoy (Viderö) Island (loc. 1)

Very fine chabazite occurs at a small quarry along the road between Hvannasund and Viðareiði. Crystals range in size from 1 to 4 cm and are associated with micro heulandite.

Norðdepil, Borðoy (Bordö) Island (loc. 2)

A rich zeolite assemblage including chabazite, heulandite, levyne, mesolite, stilbite and thomsonite, and also calcite and apophyllite, occurs at an abandoned quarry south of Norðdepil.

Norðoyri, Borðoy (loc. 3)

Along the shoreline south of Norðoyri (Nordöre) stilbite is very abundant. Görgey (1910) reported the richest occurrence of levyne as located in the Torvadalsá Valley (Thorvadas-Aa) southeast of Norðoyri.

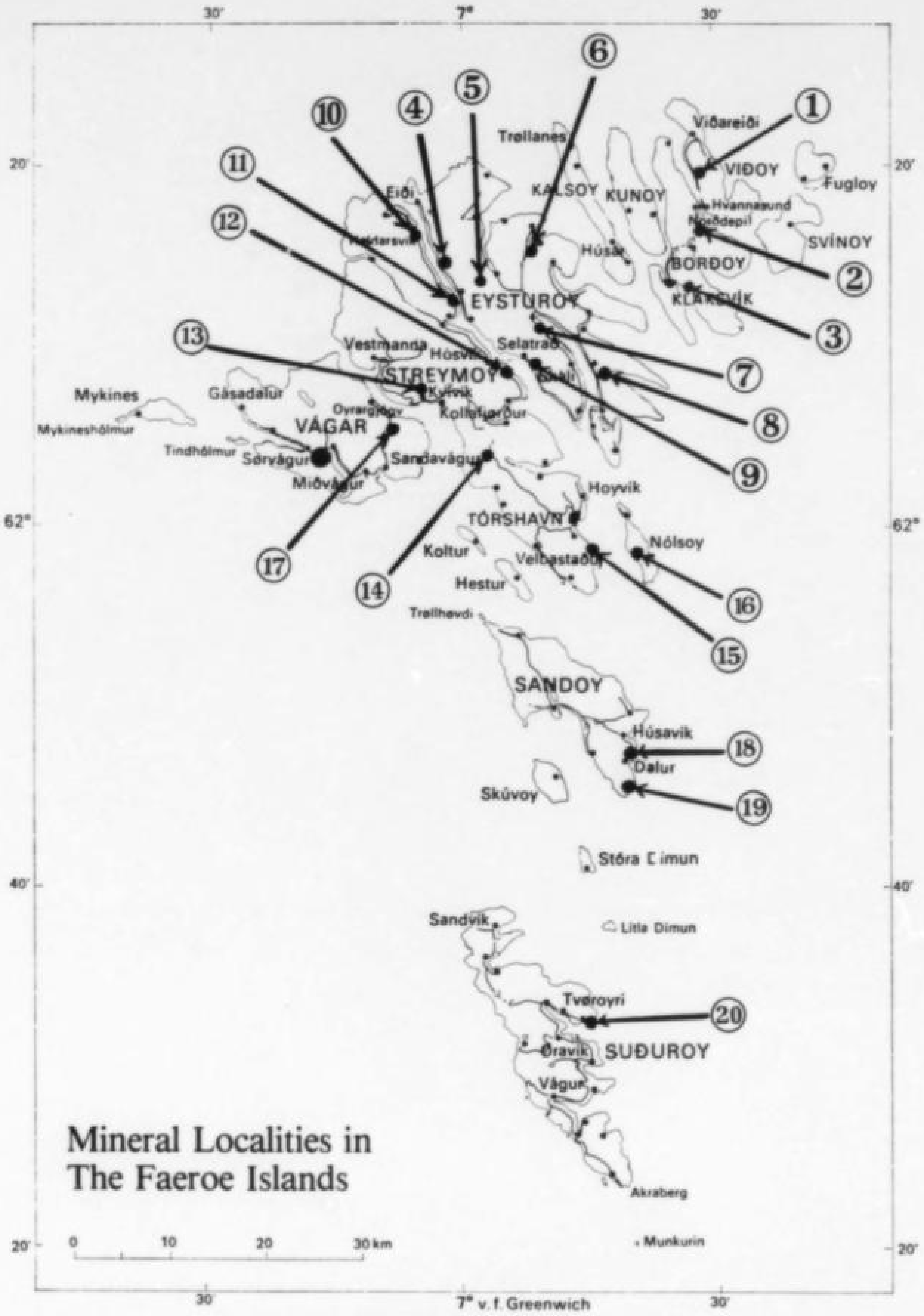

Figure 6. **Mineral localities in the Faeroe Islands.**

Ljósá, Eysturoy (Österö) Island (loc. 4)

A roadcut near Ljósá has exposed fresh rock very rich in thomsonite, gyrolite, apophyllite, chabazite and analcime crystals to 3 cm.

Lítlafelli, Eysturoy (loc. 5)

In 1977 a tunnel was opened near Lítlafelli. Dumps near the northern portal contain thomsonite, stilbite, mesolite, apophyllite and calcite.

Hjardarðalur, Eysturoy (loc. 6)

Very fine, large specimens of stilbite and apophyllite have been collected from a roadcut at Hjardarðalur.

Skálafjørður, Eysturoy (loc. 7)

Very fine specimens of mesolite with stilbite, heulandite and apophyllite have been collected from an abandoned quarry southeast of the village of Skálafjørður.

Lambareiði, Eysturoy (loc. 8)

Several small quarries are being operated near Lambareiði, but they produce only small chabazite crystals. A fine specimen with chabazite crystals to 3 cm was found along the road to Hæddin.

Selatrað, Eysturoy (loc. 9)

Fine specimens of stilbite, chabazite and apophyllite have been collected at a small abandoned quarry near Selatrað.

Haldarsvík, Streymoy (Strömö) Island (loc. 10)

A small abandoned quarry near Haldarsvík is very rich in stilbite associated with heulandite and apophyllite. Along the road nearby, two pockets about 50 cm in diameter contained a very attractive assemblage of mesolite, heulandite, stilbite and apophyllite.

Nesvík, Streymoy (loc. 11)

A major quarry near Nesvík has produced large crystals of levyne, and also thomsonite, gyrolite, apophyllite and mesolite.

Hósvík, Streymoy (loc. 12)

Along the road between Hósvík and Kollafjørður there is a large factory constructed in an old quarry. A boulder there contained a nice assemblage of stilbite, apophyllite and chabazite.

Kvívík, Streymoy (loc. 13)

Some large cavities containing zeolites have been exposed in a roadcut near Kvívík. Most notable of these was a pocket about 2 m long and 60 cm in thickness, filled with mud and heulandite, mesolite, stilbite and laumontite.

Sátan, Streymoy (loc. 14)

Near Sátan on the Thorshavn-Vestmanna road there is a large

Figure 7. **Búlandstindur (Búlands Peak) at the southern mouth of Berufjörður, Iceland.**

Figure 8. **A collector with full backpack heads out from Berufjarðarádalur, toward the slopes of Rauðafell (Rauða Mountain) in the Berufjörður (Beruf Fjord).**

Figure 9. **The rugged bank of the Berufjörður near Teigarhorn consists of Tholeiite riddled with zeolite-filled pockets.**

quarry containing chabazite, stilbite, apophyllite and other species. The author collected a specimen of chabazite with thomsonite, mesolite and cowlesite; cavities containing levyne are also present.

Glyvursnes, Streymoy (loc. 15)

This locality south of Thorshavn was described by Görgey (1910) as zeolite-rich. Some nice specimens of chabazite and stilbite with heulandite were collected there in 1973.

Skútin, Nólsoy (Naalsö, Nolsö) Island (loc. 16)

Many museum specimens of Faeroes zeolites are from the famous locality at Skútin. Old maps show the additional name of Zeolithhule (= "zeolite cave") at Nólsoy. Access is difficult by land but easy by boat. The widely known specimens of thomsonite *(faeroelite),* stilbite and long, prismatic apophyllite were still to be found there at the time of the author's visit in 1972.

Vágar (Vaagö) Island (Loc. 17)

Much road construction has taken place in recent years between Sandvágur and the ferry station at Oyrargjógv. Zeolites occur at several locations along the roadcut. Most remarkable was a large pocket still visible along the road near Lidarhamar. This pocket, about 1 by 2 m, was opened in 1973. The walls were coated with irregularly developed tabular stilbite crystals to 1 cm.

Dalur, Sandoy (Sandö) Island (loc. 18)

Large chabazite crystals to 4 cm were collected in a roadcut near Dalur.

Dalsnípa (Dalsnypen), Sandoy (loc. 19)

A 200-meter-high cliff at Dalsnípa on southern Sandoy is one of the most famous Faeroes localities, and the type locality for levyne. The boulders here, up to several meters in size, are rich in zeolites, the most famous being chabazite crystals to 4 cm. Apophyllite, stilbite and heulandite are also abundant. Access to this locality is difficult.

Forðbiarnípa, Suderoy (Suderö) Island (loc. 20)

One of the occurrences of native copper with zeolites mentioned by Cornu (1907) is located near Forðbiarnípa. The author found copper with scolecite and mesolite there, near a coal outcrop in 1973.

Figure 10. **The author collecting in a pocket in a roadcut near Kvívík, Streymoy Island, Faeroes. Photo by Klaus Petitjean.**

Figure 11. **Dalsnípa, the type locality for levyne, on Sandoy Island, Faeroes.**

Figure 12. **Lítla Dímun Island in the Faeroes.**

Figure 13. **A colorless, 5-mm analcime crystal on chabazite, from Heiðarvatn, Breiðdalsheiði, Iceland. Collection of the author. (This and all other photos in this article, except Fig. 10, were taken by the author; the specimens shown are all from the author's collection, except for that in Figure 35.)**

ZEOLITE MINERALS

Analcime

Well developed crystals of analcime showing the usual trapezohedron {211} are widely distributed in Iceland (locations 2, 4, 6, 8), but crystals are typically very small. Fine specimens showing fresh, colorless crystals to 2 cm and more occur in the analcime zone or eastern Iceland (locations 11, 12, 14, 15).

Analcime is relatively rare in the Faeroes, as indicated by Görgey (1910), but it has been found to be locally abundant at Eysturoy (location 4), where it forms fine crystals to more than 3 cm. A single specimen has been found on Streymoy Island (loc. 13).

Chabazite

Crystals of chabazite have been found at many locations in Iceland (loc. 1, 4, 6, 9, 10, 12, 14, 15), usually showing only the rhombohedron $\{10\bar{1}1\}$, and in size not larger than about 1 cm. Twinned crystals *(phacolite)* showing $\{11\bar{2}3\}$ are also present (loc. 8, 12).

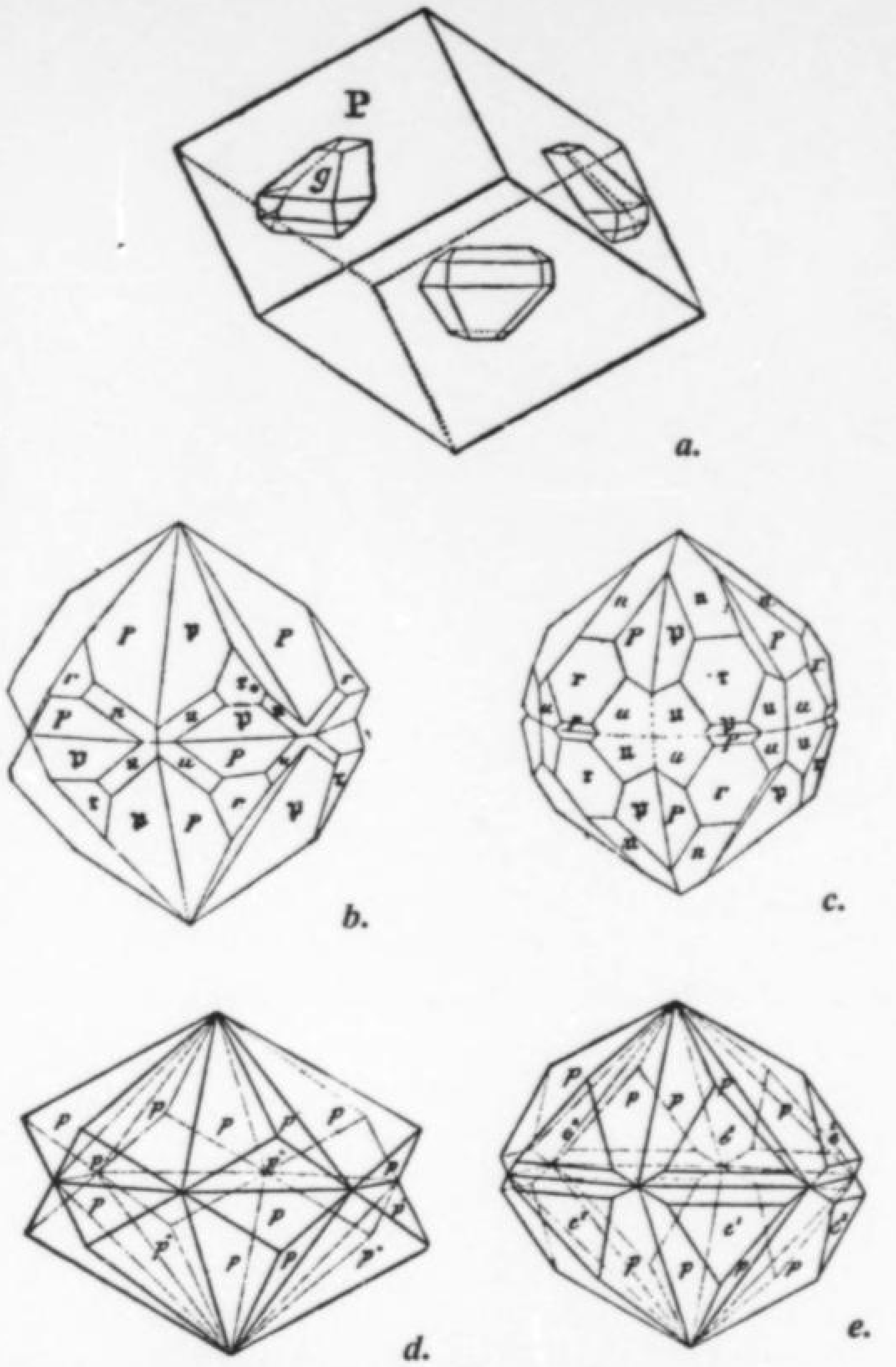

Figure 14. **Chabazite crystal drawings (from Goldschmidt, 1913);** *a* **and** *b:* **Iceland;** *c:* **Faeroes;** *d* **and** *e:* **Dalsnípa, Faeroes.**

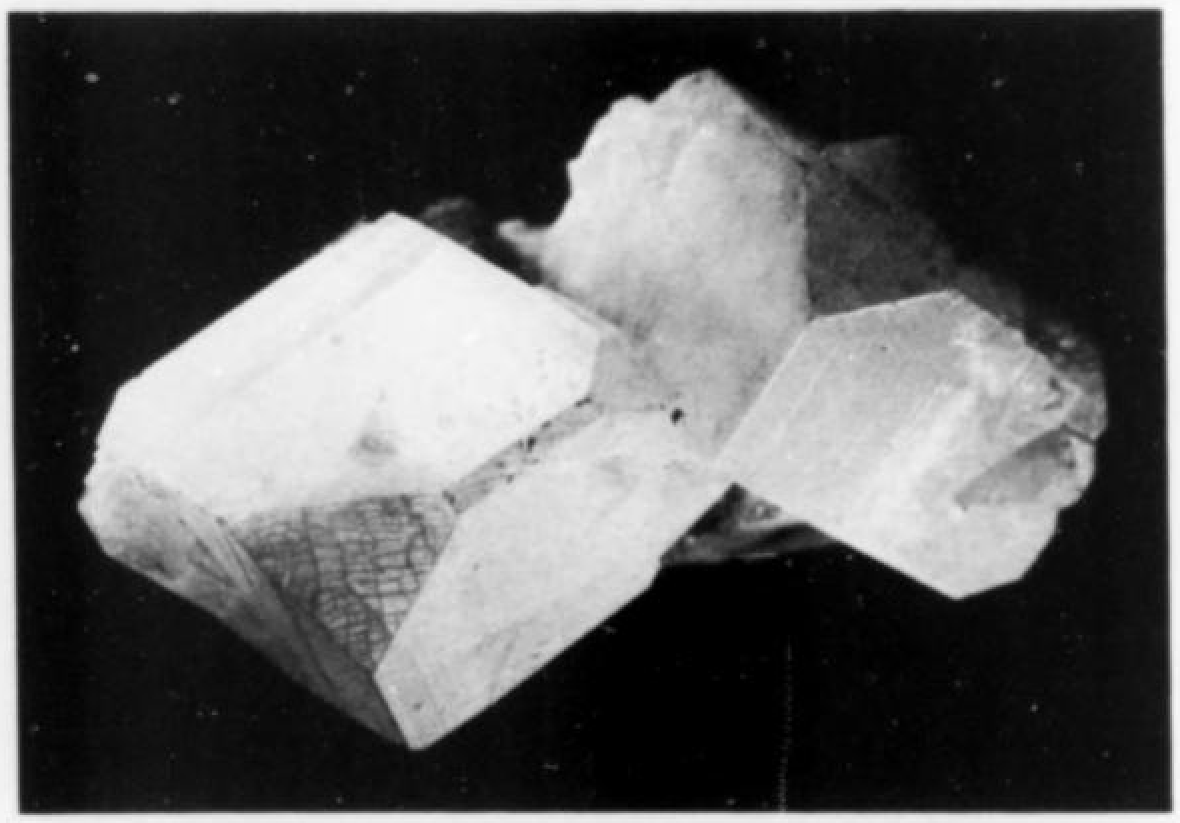

Figure 15. **A 2 by 4-cm specimen of white chabazite from Malinsfjall, Viðoy Island, Faeroes.**

Chabazite crystals form very fine specimens at several localities in the Faeroes. Crystals 2 to more than 4 cm, showing $\{10\bar{1}1\}$ and twinned on (0001) have been found on Vidoy (loc. 1), Eysturoy (loc. 8, 9) and Sandoy (loc. 18, 19) Islands. Fine crystals showing combinations of $\{10\bar{1}1\}$, $\{01\bar{1}2\}$ and $\{02\bar{2}1\}$ occur on Vidoy Island (loc. 1), and twins showing $\{11\bar{2}3\}$ occur on Bordoy (loc. 2). Crystals under 2 cm are very abundant; Currie (1907) and Görgey (1910) list together more than 100 localities.

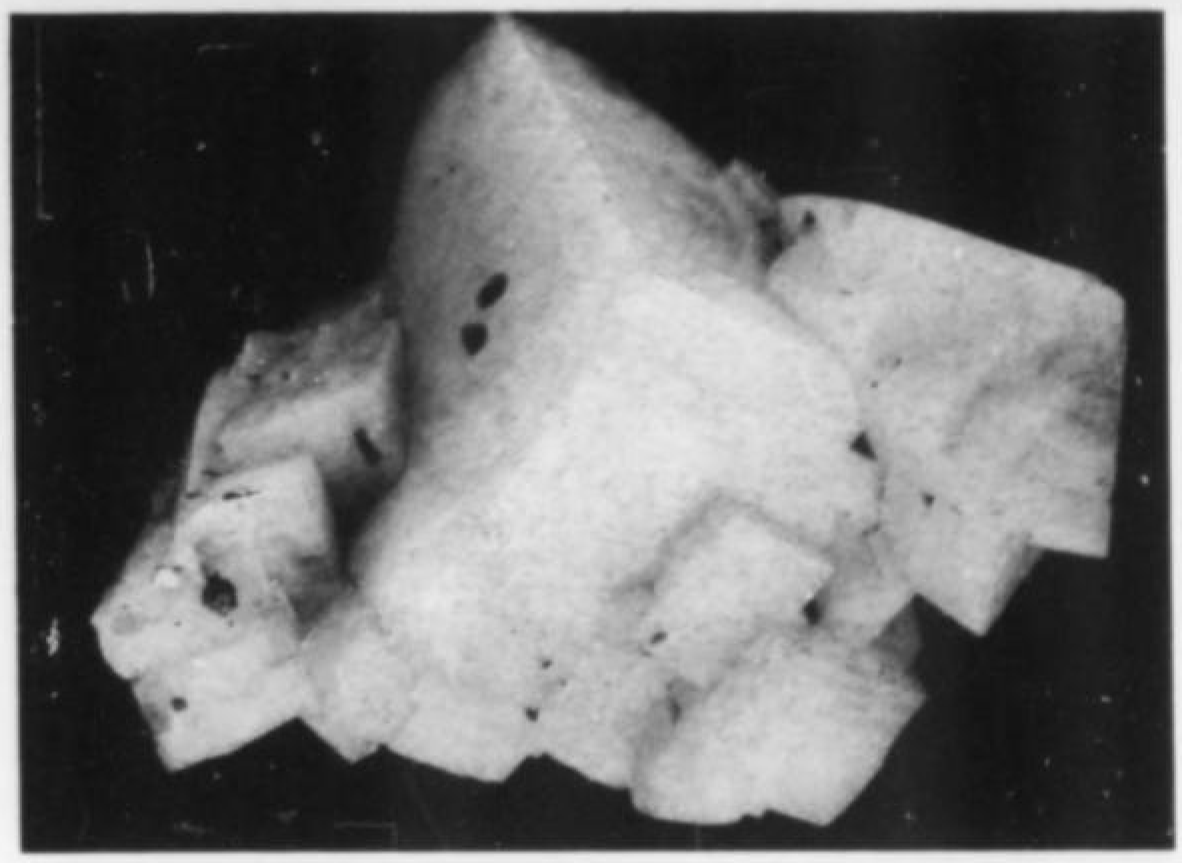

Figure 16. **White chabazite crystals 6 by 7 cm, from Dalur, Sandoy Island, Faeroes.**

Figure 17. **White cowlesite lining a cavity 1 cm wide, from Mjöadalsa, Sanddalstunga, Myrasysla, Iceland.**

Cowlesite

In Iceland, cowlesite has been found in Mjöadalsá Canyon near Hvammur (loc. 4). It occurs sparingly and alone, lining small cavities in a levyne-rich basalt. Specimens are very similar in appearance to those from Spray, Oregon, shown by Wise and Tschernich (1975).

Cowlesite has also been recognized on a Faeroes specimen (Tschernich, private communication), kept at the British Museum of Natural History in London, labeled as coming from Dalsnípa on Sandoy Island (loc. 19). Another specimen, collected on Streymoy (loc. 14), shows cowlesite lining a 5 by 10-mm cavity; other cavities on the same specimen show levyne and a chabazite-thomsonite-mesolite succession.

Epistilbite

Epistilbite crystals are known from several localities in Iceland (loc. 1, 3, 9, 15). Most of the crystals collected at Berufjörður (loc. 15) show {110} and {001}, and reach about 1 cm in size. Crystals of

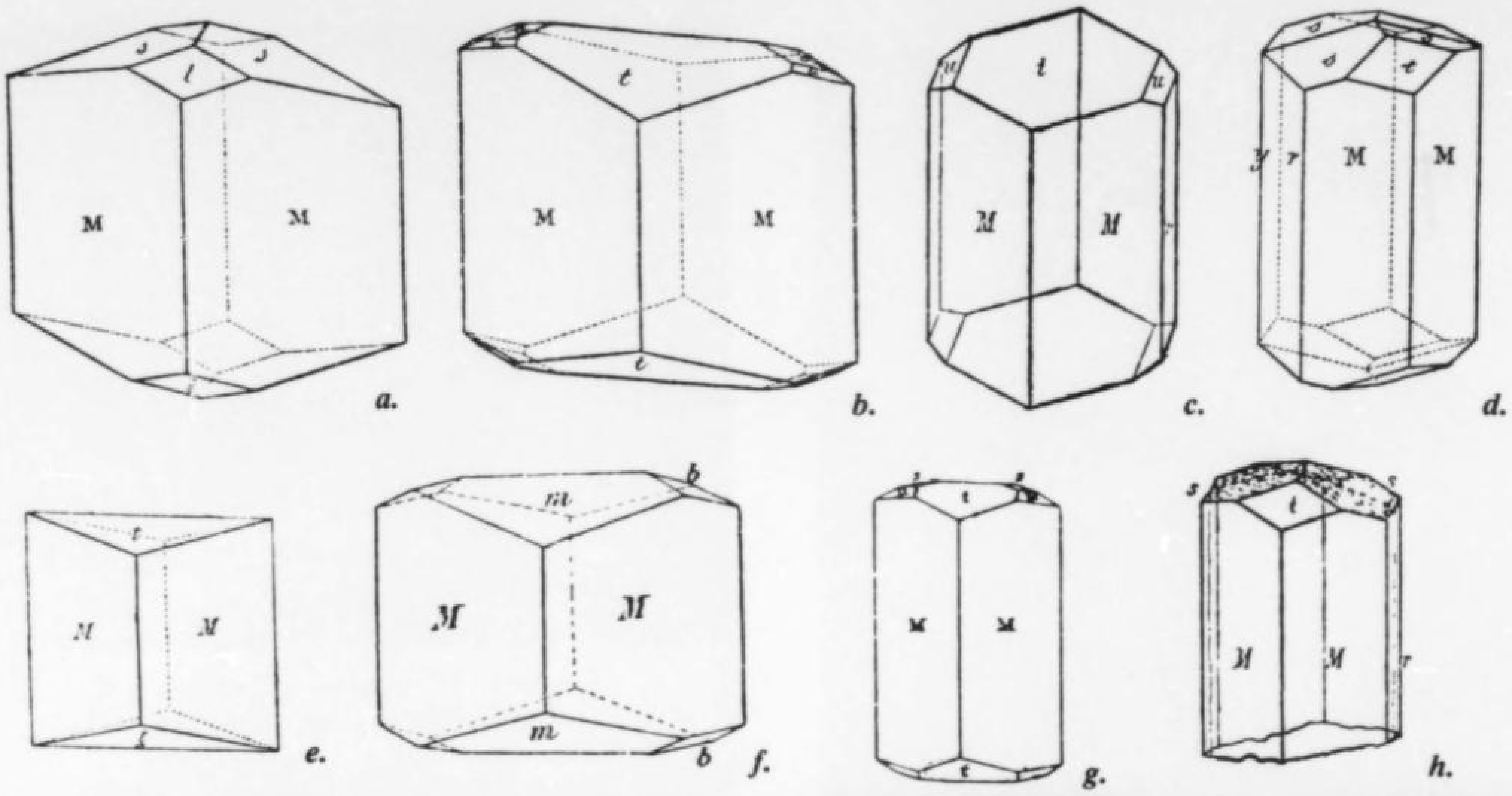

Figure 18. **Epistilbite crystal drawings (from Goldschmidt, 1916); *a, b* and *d:* Iceland and the Faeroes; *c* and *h:* Berufjörður, Iceland; *e, f* and *g:* Iceland.**

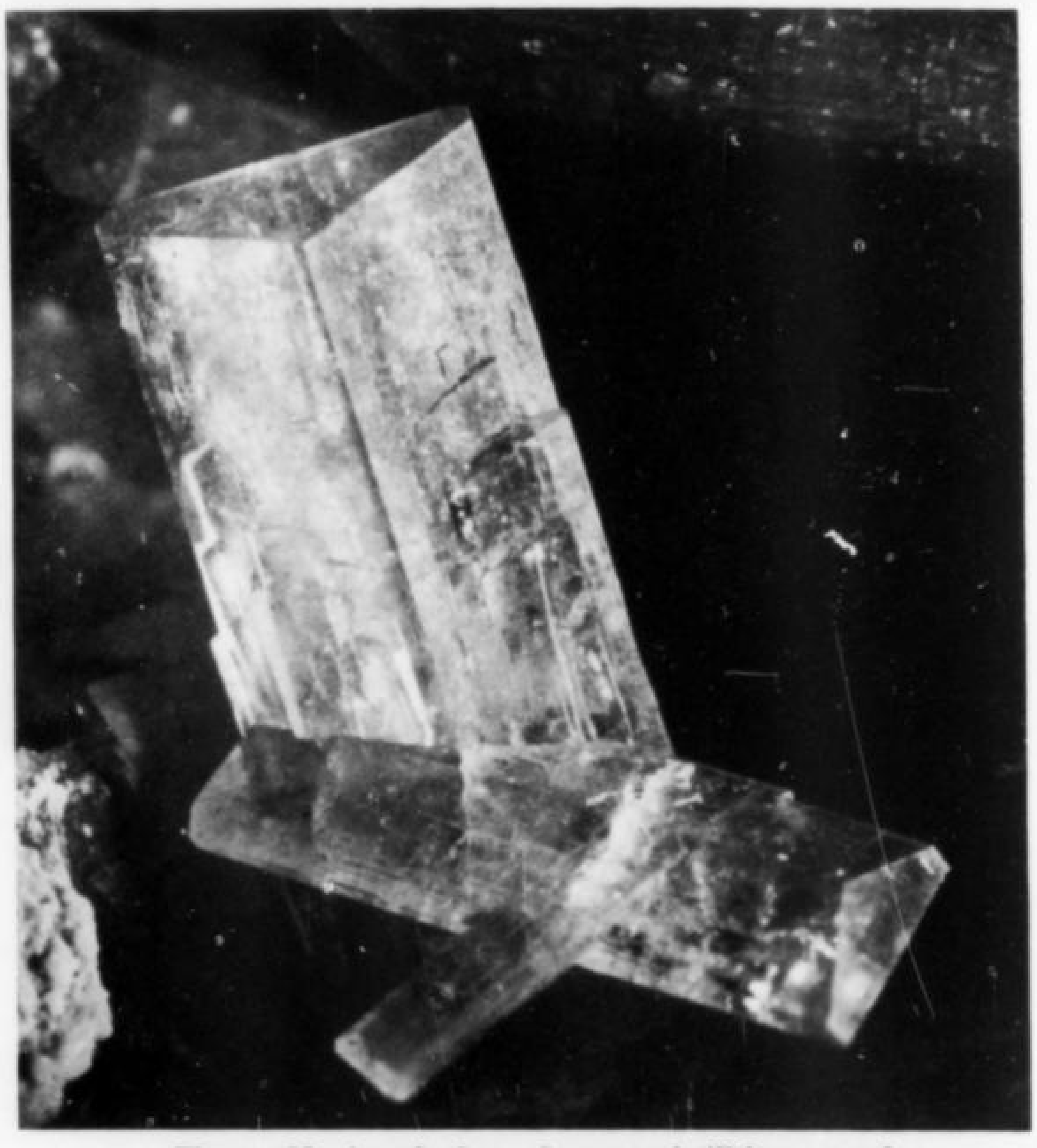

Figure 19. **A colorless, 5-mm epistilbite crystal with two smaller crystals attached, from Fossárfell, Berufjörður, Iceland.**

Figure 20. **A colorless, 2.8-cm multiple crystal of epistilbite with acicular mordenite, from Fossárfell, Berufjörður.**

this type are sometimes multiply twinned and aggregated to form larger, very irregular "crystals" which are tabular on {110} and have very uneven "faces." The largest crystals of this type measure about 2.5 cm. Though rather rare (Walker, 1960) epistilbite was found abundantly in a small zone 2 by 5 m at Fossarfell, where it lined small cavities 3 to 8 cm in diameter. Associations include mordenite, heulandite, chabazite, calcite and, in a few cases, stilbite. Only a few specimens have been found at other locations in the Berufjörður (at Rauðafell and Titlingshagi). Crystals collected at Eyafjörður (loc. 9) are small, only a few mm long. These crystals show the prism {110} and are terminated mainly by {112}, but crystals terminated by {001} are also present.

Epistilbite has been reported as being present on the Faeroes, but neither Currie (1907) nor Görgey (1910) give specific localities. The author too has been unable to find any epistilbite on the Faeroes.

Garronite

Garronite has been reported from 21 localities in eastern Iceland by Walker (1962a). It occurs as radiating, compact amygdules.

Gismondine

Gismondine has been reported from 21 localities in eastern

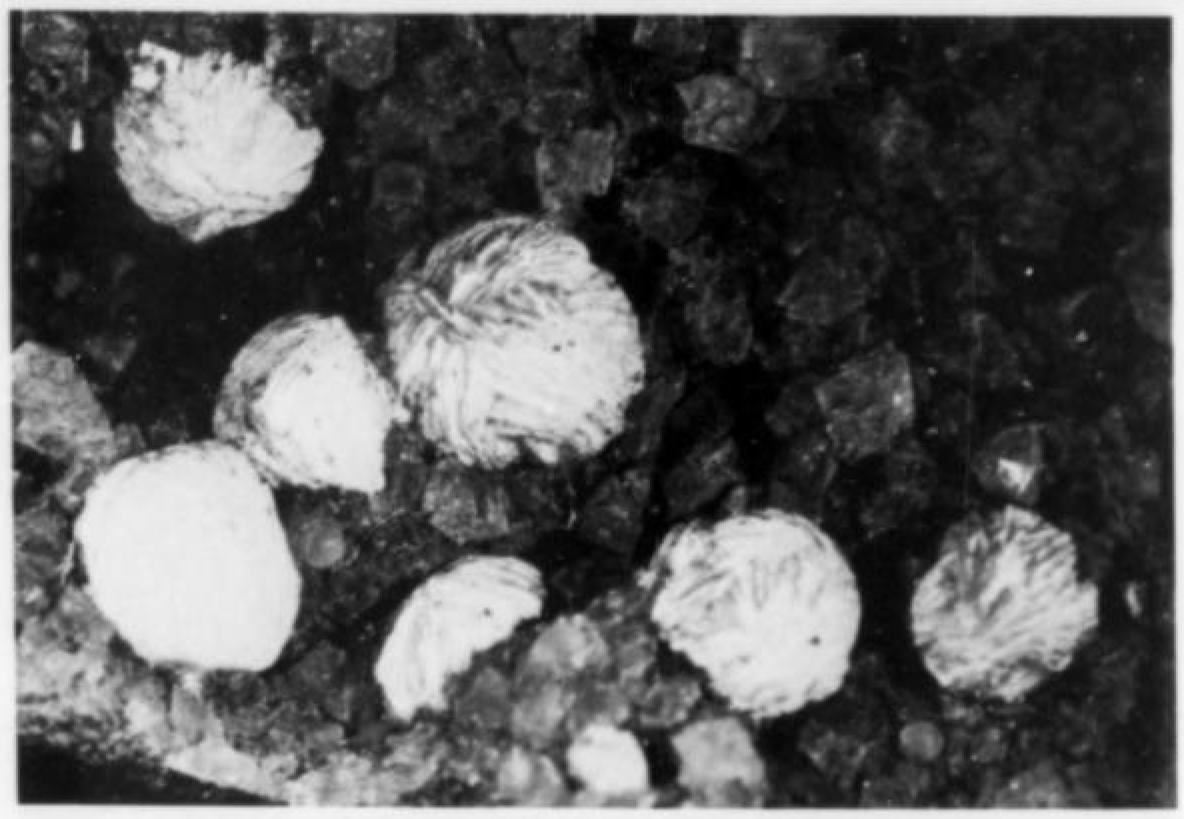

Figure 21. **White, spherical, crystal aggregates 3 to 4 mm wide, of low-potassium gismondine from the northwest slope of Skagafell, west of Reydarfjörður, Iceland.**

Iceland by Walker (1962b). All occurrences are above 500 m in altitude, as is also the case with garronite. Fog and cloud cover rarely allow collecting at this elevation; the author has collected gismondine only on the northwest ridge of Skagafell (loc. 10) (Walker loc. No. G25). It is locally abundant, forming irregular, chalk-white aggregates and spherules to 5 mm composed of pseudo-octahedral twins. In many cases crystal faces are not discernible. Most specimens show the succession chabazite-gismondine-thomsonite. One specimen has calcite as the earliest mineral and contains abundant levyne.

Faeroes gismondine was identified by Claringbull and Hey (1952) on a specimen collected by Currie at Sundelaget on Streymoy Island (near loc. 11).

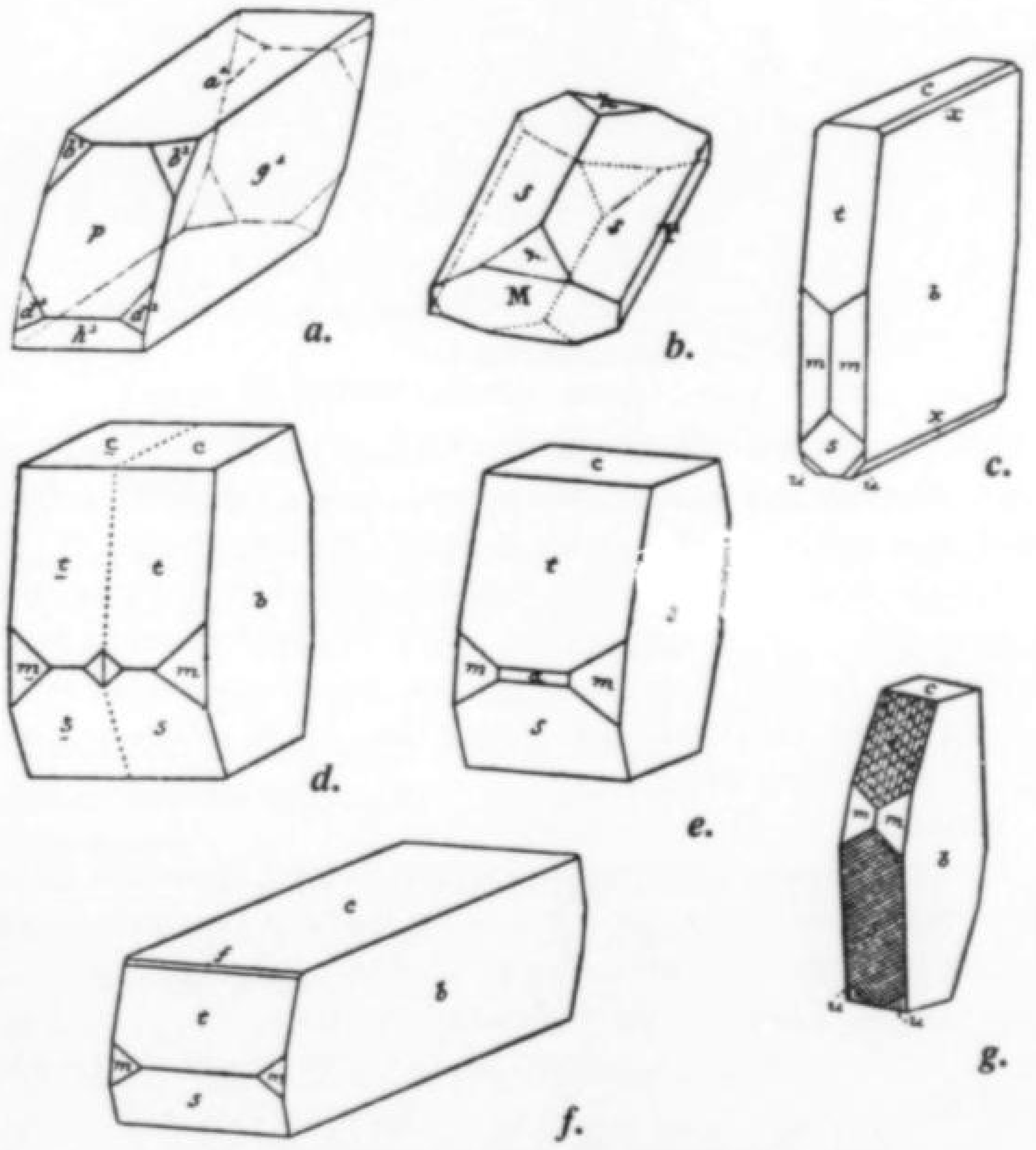

Figure 22. **Heulandite crystal drawings (from Goldschmidt, 1918);** *a:* **Iceland;** *b:* **Faeroes;** *c:* **Miðwágur, Faeroes;** *d* **and** *e*: **Lítla Dimun Island, Faeroes;** *f:* **Hafjall, Faeroes;** *g:* **Futaklettur, Faeroes.**

Figure 23. **A white, 3-cm heulandite crystal from Bulandstindur, Berufjörður, Iceland.**

Heulandite

Heulandite occurs abundantly in Iceland at many localities (loc. 1, 5, 9, 11, 14, 15, 17). Exceptional specimens have been found in eastern Iceland, principally at Berufjörður. Museum specimens from Teigarhorn show well developed crystals to 10 cm. Singles to 7 cm have been found lying in the gravel slopes at Fossarfell and Rauðafell, and fine specimens have been found at Búlandsdalur, Fossárfell, Rauðafell and Dúfuklettur. Crystals commonly show {010}, {001}, {201}, {111} and {100}, the latter form always small. Some crystals show a curvature of {010} and others a twist on [010] up to 90°.

Heulandite is widely distributed on the Faeroes as well, but the appearance is remarkably different from that of Iceland heulandite. Micro heulandite crystals commonly cover the walls of cavities and are associated with larger, well developed crystals of other zeolites and apophyllite (loc. 1, 2, 3, 6, 7, 8, 9, 10, 13, 17). Crystals exceeding 5 mm are less abundant (loc. 7, 10, 15, 19), and exceptional specimens have not been found on the Faeroes.

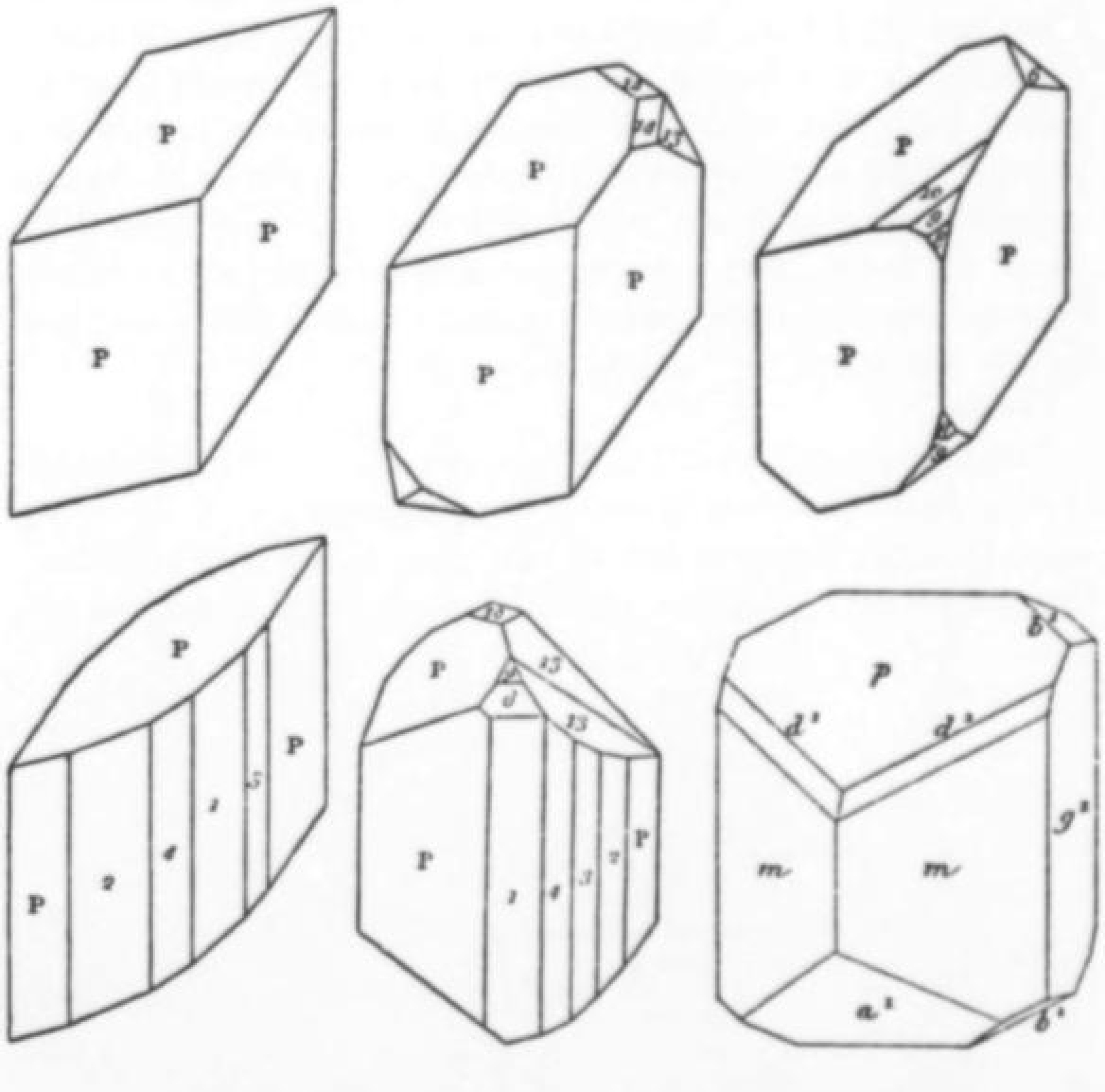

Figure 24. **Laumontite crystal drawings (from Goldschmidt, 1918), all of crystals from Hvelgöet, Faeroes.**

Figure 25. **A 1.5-cm "bow-tie" of white laumontite with reddish brown stilbite from Gasafelli, Vagar Island, Faeroes.**

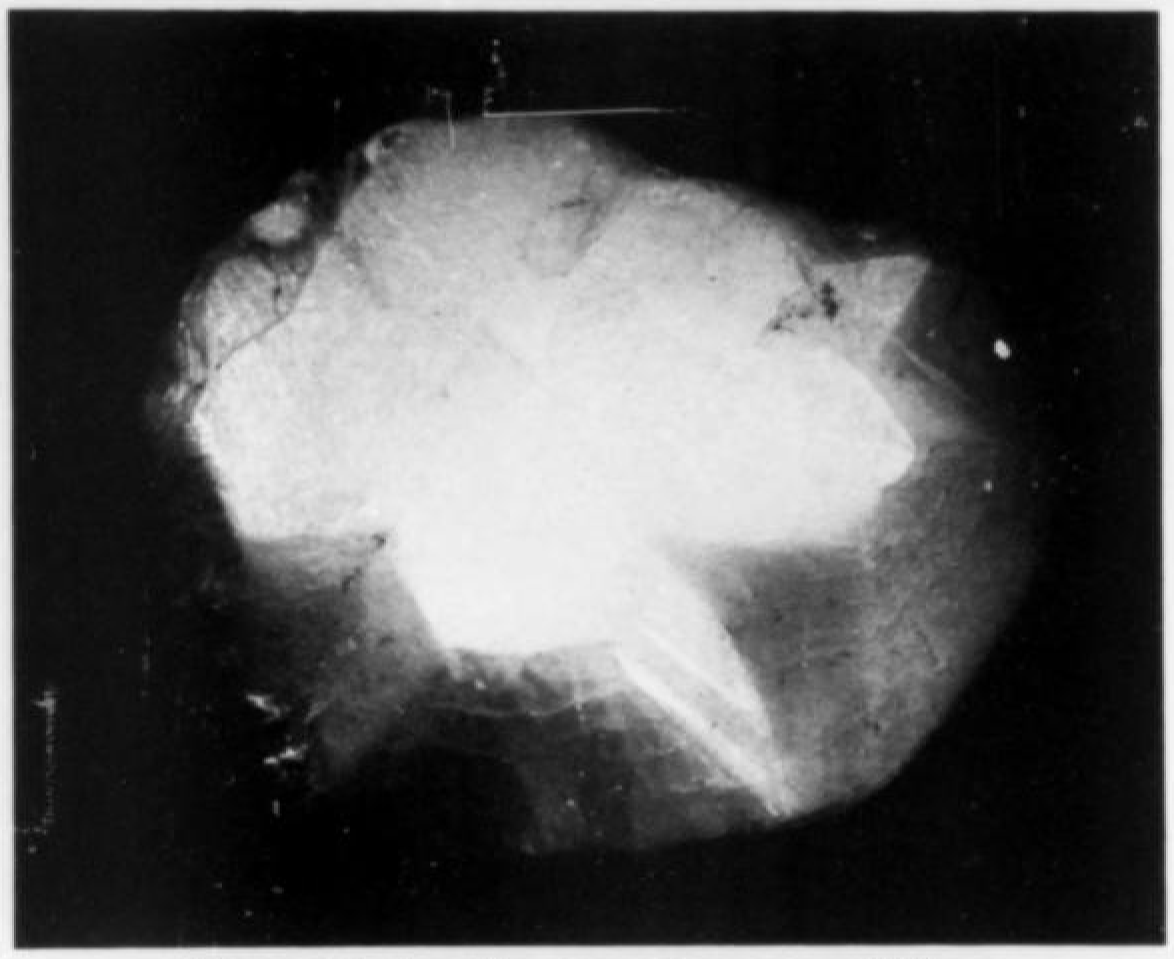

Figure 27. **A white, 3-cm levyne crystal from Rossafelli, Streymoy Island, Faeroes.**

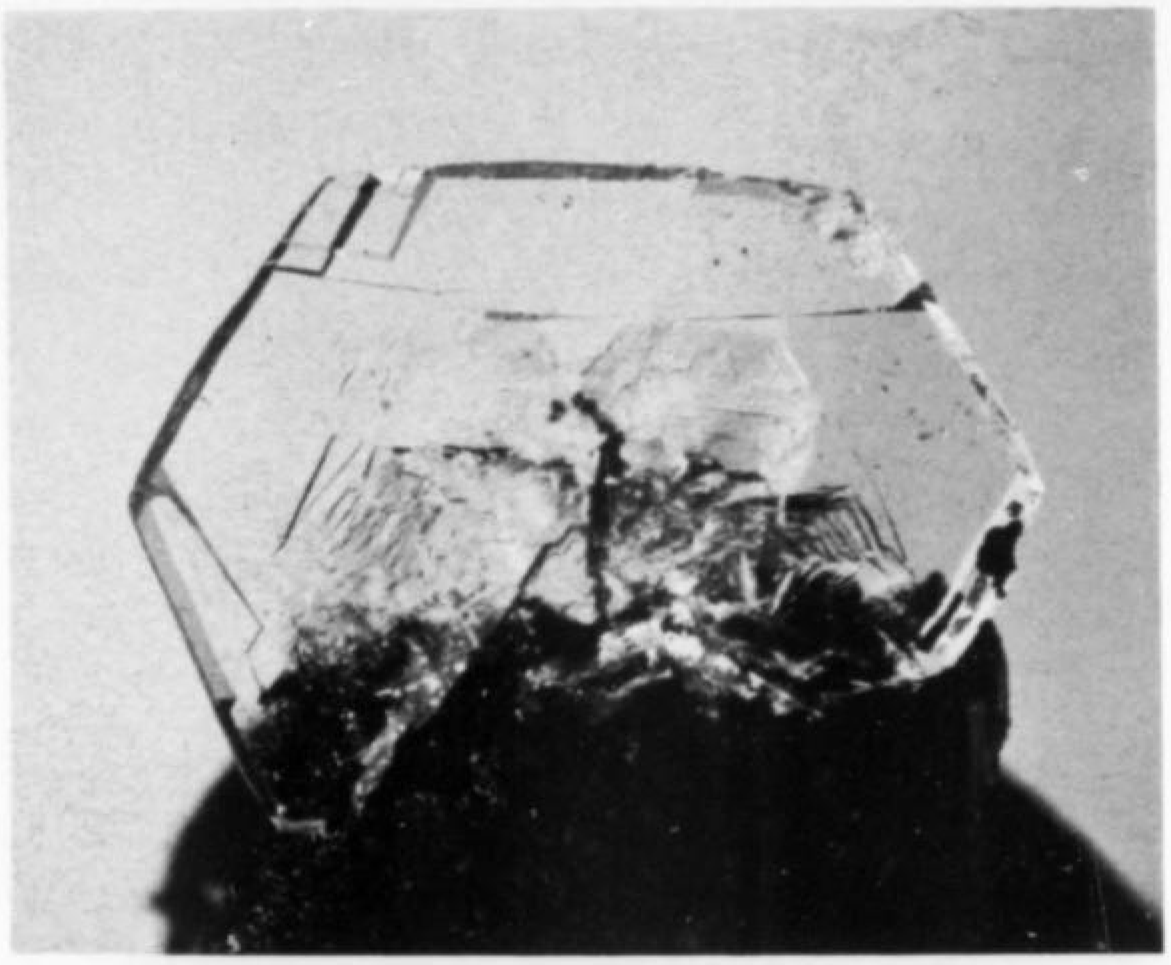

Figure 28. **A transparent, colorless, 3-mm crystal of levyne from Mjöadalsa, Sanddalstunga, Myrasysla, Iceland.**

Laumontite (in part, leonhardite)

In Iceland, dehydrated laumontite was found abundantly as powdery fillings of small cavities south of Skíðastaðir (loc. 7). Crystals are present but they easily disintegrate to white powder. There is a similar occurrence at Skaftafellsjökull, a few hundred meters northeast of the campsite (near loc. 17). Small but well developed, white, opaque, prismatic crystals to 1 cm showing {110} and {201} form part of the zeolite assemblage at Helgustadanama (loc. 11) and are also present at Hafrafell (loc. 17). Jakobsson (1977) lists laumontite as being present at Teigarhorn, and Walker (1960) records it from Breiðdalur-Berufjörður (loc. 14, 15).

According to Görgey (1910), laumontite is rare on the Faeroes. It was found very rich in a cavity at Vágar (loc. 17), in association with tabular stilbite. Laumontite forms radiating aggregates and "bow-ties" to 1.5 cm, usually colorless and translucent. If kept in sealed boxes in a humid atmosphere they will remain clear for several years, but in dry air laumontite dehydrates rapidly to a white, opaque and fragile state (leonhardite). A similar occurrence of laumontite was found near Kvívík (loc. 13) only about 4 km across the Sund. Here it occurs partially as inclusions in stilbite. Poor specimens of laumontite on thomsonite have been found near Kvívík, and some small crystals near Ljósá (loc. 4).

Levyne

Tabular, twinned crystals of levyne showing {0001}, {10$\bar{1}$1} and {10$\bar{1}$2} occur at several localities in Iceland (loc. 1, 4, 6, 9, 10). Many localities in eastern Iceland were reported by Walker (1962a). Crystals are usually opaque white and under 5 mm in size, but colorless, translucent crystals are also known. Levyne can be locally very abundant and is commonly present alone in cavities. Garronite and gismondine typically occur close by (Walker, 1962a).

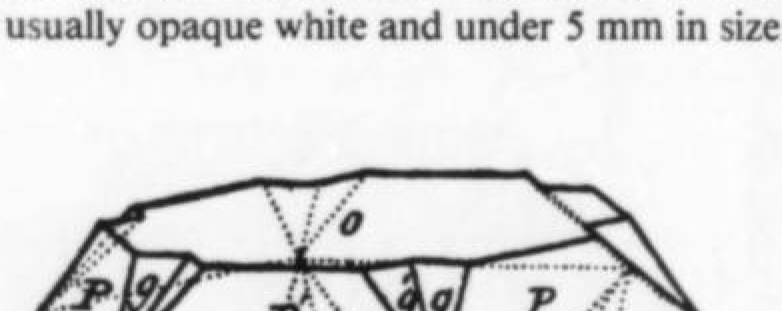

Figure 26. **Levyne crystal drawing (from Goldschmidt, 1918), based on a crystal from Dalsnípa, Faeroes.**

Levyne is known from many localities in the Faeroes reported by Currie (1907) and Görgey (1910). It has also been found at Norðdepil (loc. 2) and Sátan (loc. 14). One exceptionally large crystal (about 3 cm) was found near Nesvik (loc. 11) in association with gyrolite and thomsonite.

Mesolite

Mesolite is very abundant in eastern Iceland, especially in the Breiðdalur-Berufjörður area. It is easily found in the olivine basalt talus around Búlandstinður, Fossárfell, Rauðafell, Grjothólatindur and Ósfjall. Radiating aggregates and masses to 30 cm are common. Scolecite occurs in association and may be intergrown with mesolite.

Fine crystals specimens are rare. Occasionally crystals showing {110} and {111} are found. Rare crystals as long as 5 cm are known.

Mesolite occurs at Hvalfjörður (loc. 1), where it forms spherules of white, fibrous crystals to 1 cm, and well developed single crystals to 1 cm in length and 1 mm wide.

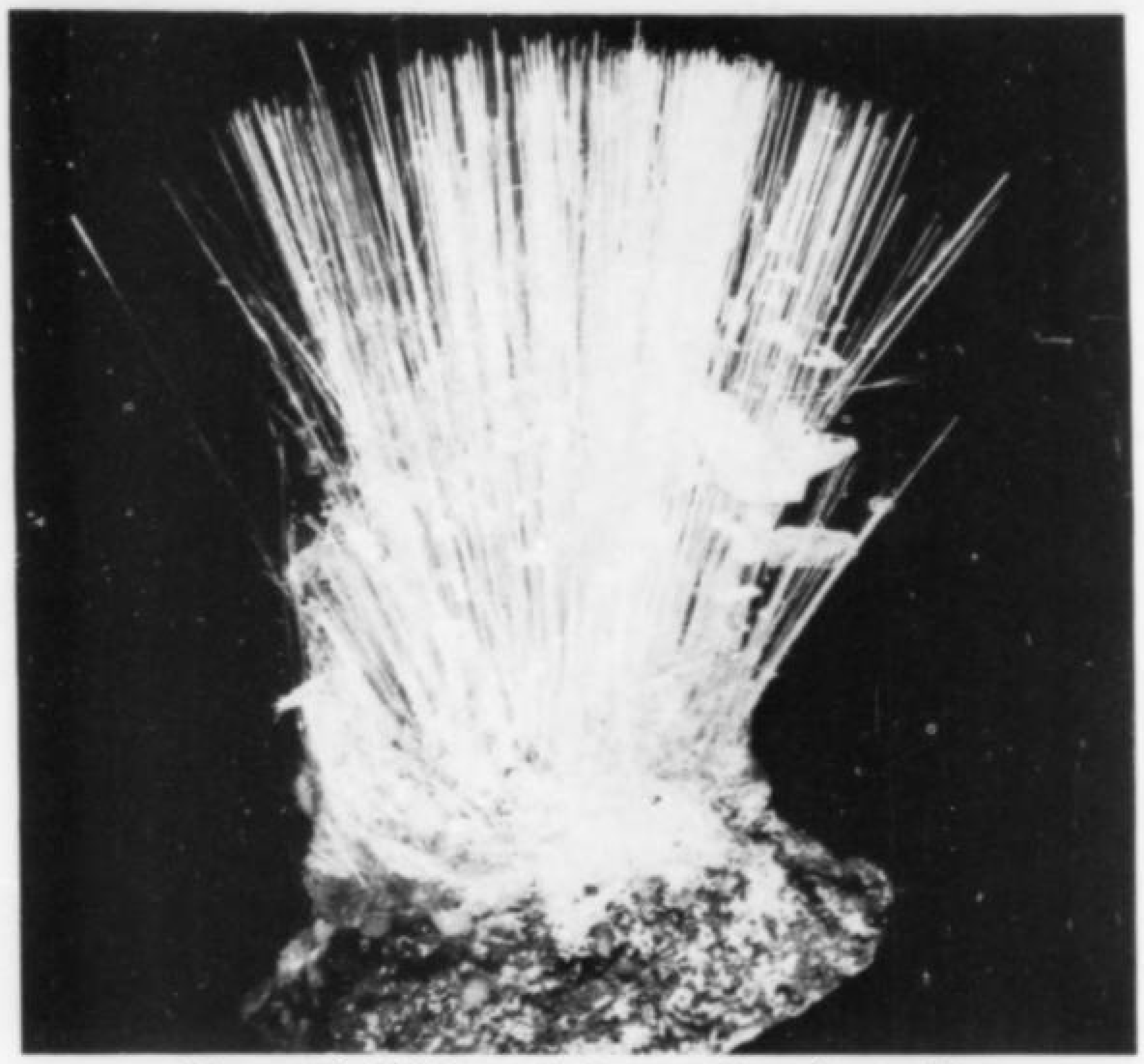

Figure 29. **White, acicular needles of mesolite about 6 cm long, with small white stilbite crystals, from Skalafjörður, Eysturoy Island, Faeroes.**

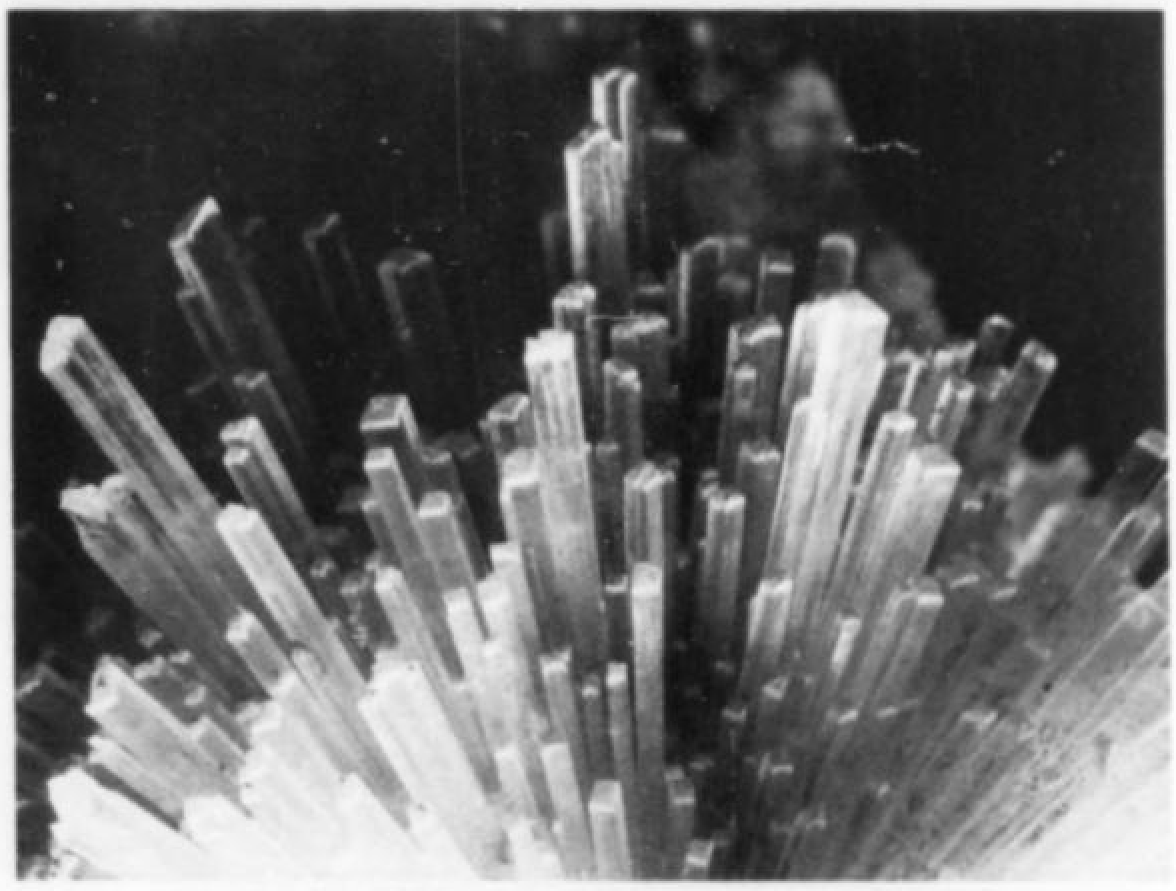

Figure 30. **White mesolite crystals, each about 0.5 mm wide, from Hvaleyri, Hvalfjörður, Iceland.**

Mesolite crystals represent the most spectacular zeolite specimens to be found on the Faeroes. Fine specimens have been collected at locations 2, 4, 7, 10 and 11. Crystals range in size up to 10 cm long and 1 mm thick; they are colorless and water-clear. Mesolite weathers very rapidly when exposed on the surface, however, and good crystals are rather rare.

Mordenite

Mordenite from Iceland was originally described as *flokite* by Callisen (1917). It is mentioned as being abundant in the tholeiites of the Breiðdalur-Berufjörður area (loc. 14, 15) by Walker (1960) and also occurs in other areas (loc. 1, 2, 5). A further occurrence is at Gljúfurá, Vestur-Húnavatnssýsla. It forms fibrous, white cavity linings and fillings, and extremely thin acicular crystals to 2 cm in length; specimens are rare owing to the rapid weathering of mordenite on the surface.

In the Faeroes mordenite has been found as acicular crystals on some specimens from Dalsnípa, Sandoy Island (loc. 19).

Phillipsite

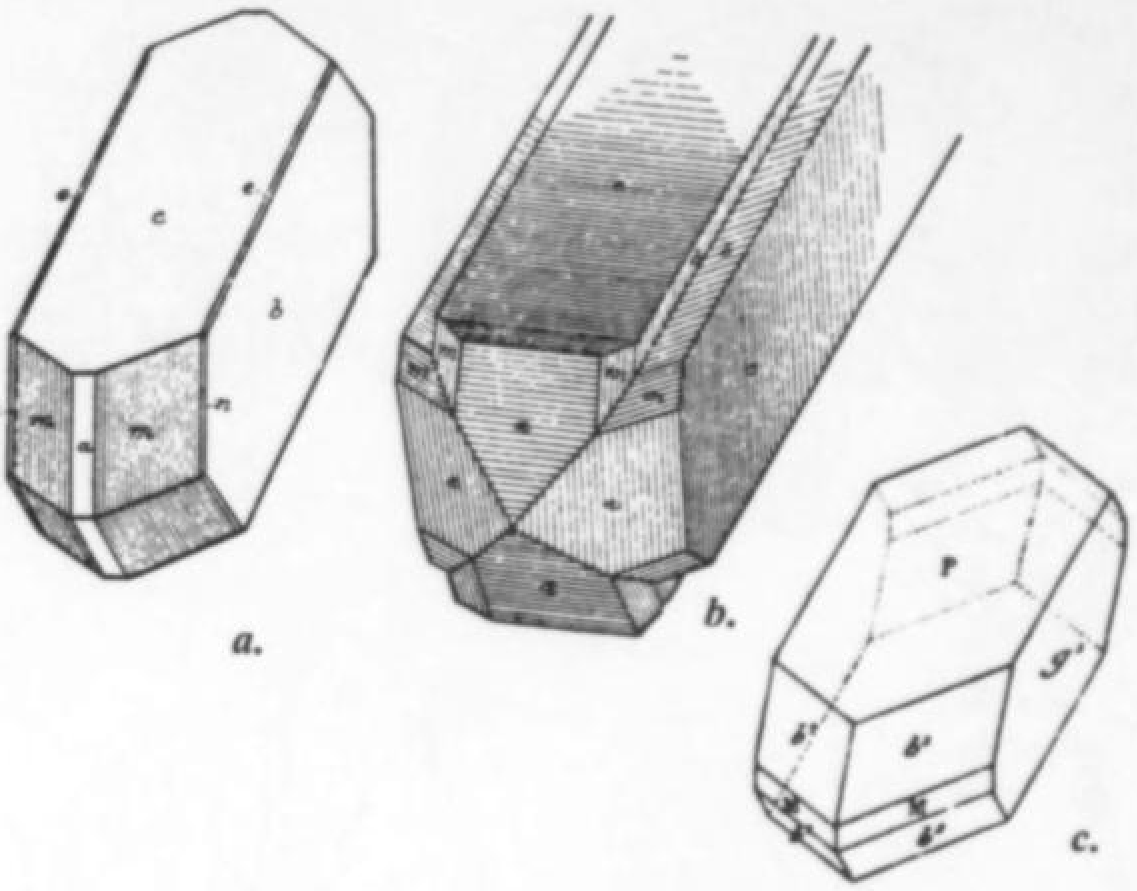

Figure 31. **Phillipsite crystal drawings (from Goldschmidt, 1920);** ***a:*** **Husadalur, Faeroes;** ***b:*** **Halvgafelli, Faeroes;** ***c:*** **Iceland.**

Phillipsite occurs primarily in the chabazite-thomsonite zone of the eastern Icelandic olivine basalts (Walker, 1960, 1962a, 1962b). Nice specimens have also been collected at Norðurádalur (loc. 8), where it forms opaque, white twins up to 8 mm in size showing {001}, {010} and {101}.

Phillipsite is found only as very small crystals on the Faeroes (Currie, 1907; Görgey, 1910).

Scolecite

Scolecite occurs in the olivine basalts of the Breiðdalur-Berufjörður area, in the same localities as mesolite (q.v.). Attractive specimens in museums generally consist of crystals in cavities from Teigarhorn (loc. 15), and are rather rare. The scolecite crystals are commonly twinned, reaching 1 by 10 cm, colorless and translucent.

Scolecite is also present in the Faeroes, at several localities mentioned by Currie (1907). The author has found it only on a poor specimen from Suderoy (loc. 20), intergrown with mesolite and associated with native copper.

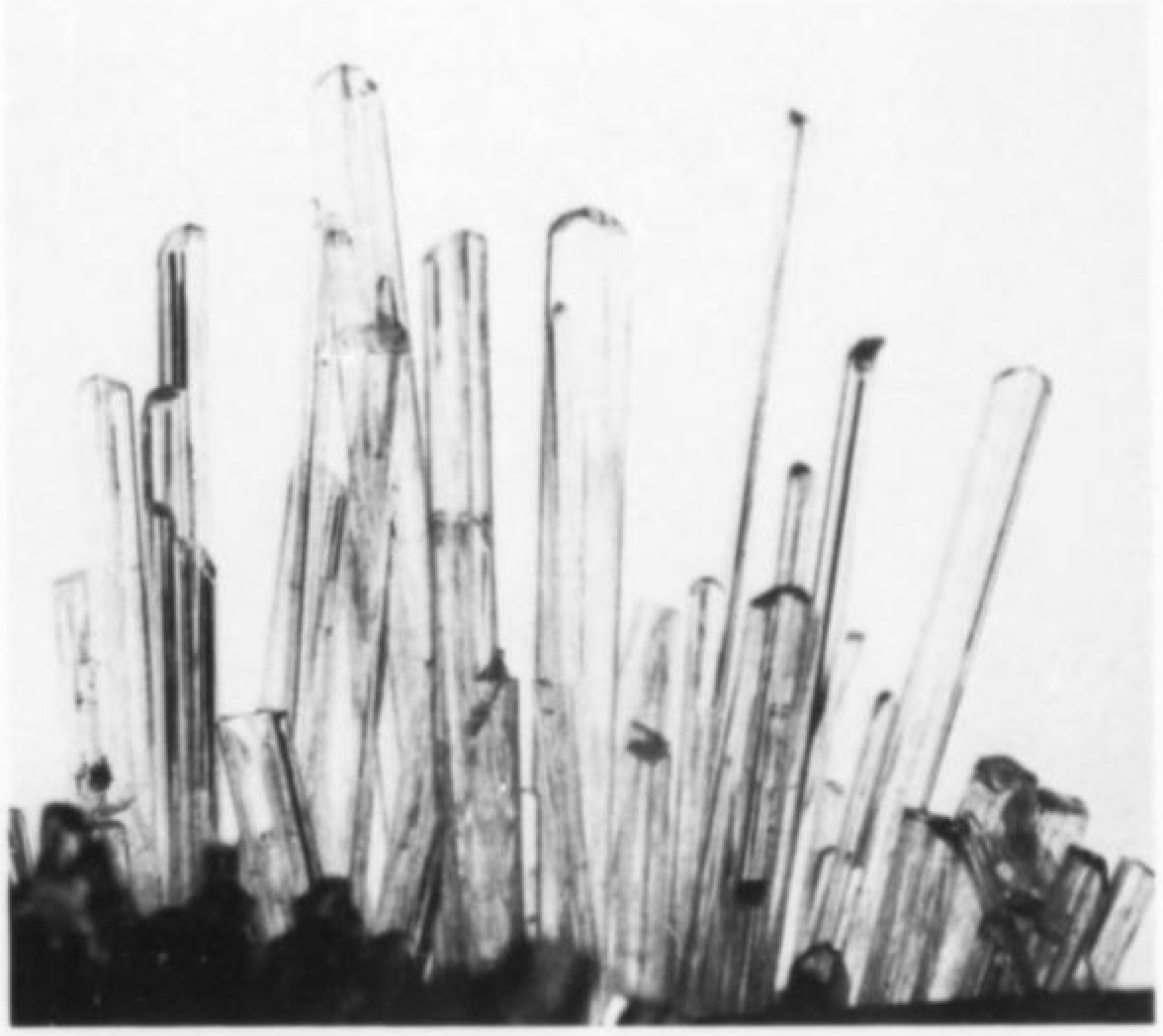

Figure 32. **Colorless, 1-cm scolecite crystals from Teigarhorn, Berufjörður, Iceland.**

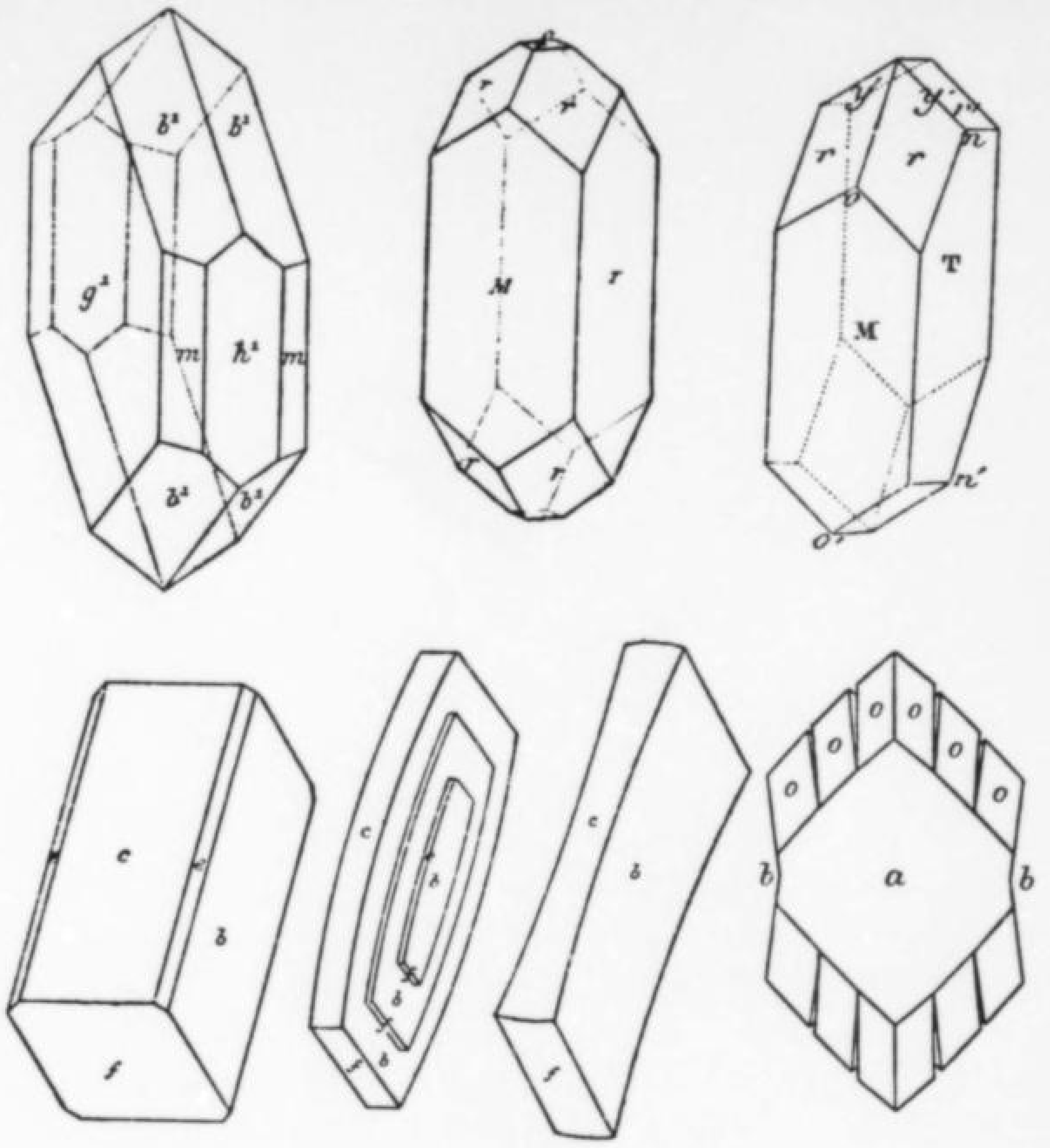

Figure 33. **Stilbite crystal drawings (from Goldschmidt, 1916); all based on Faeroes crystals except the lower right drawing, based on an Icelandic crystal.**

Figure 34. **A white, 8-cm group of stilbite crystals from Rauðafell, Berufjörður, Iceland.**

Figure 35. **A 2.5-cm, doubly terminated crystal of white stilbite (a classic "bow-tie") on quartz from Helgustaðanáma, Reyðarfjörður, Iceland.**

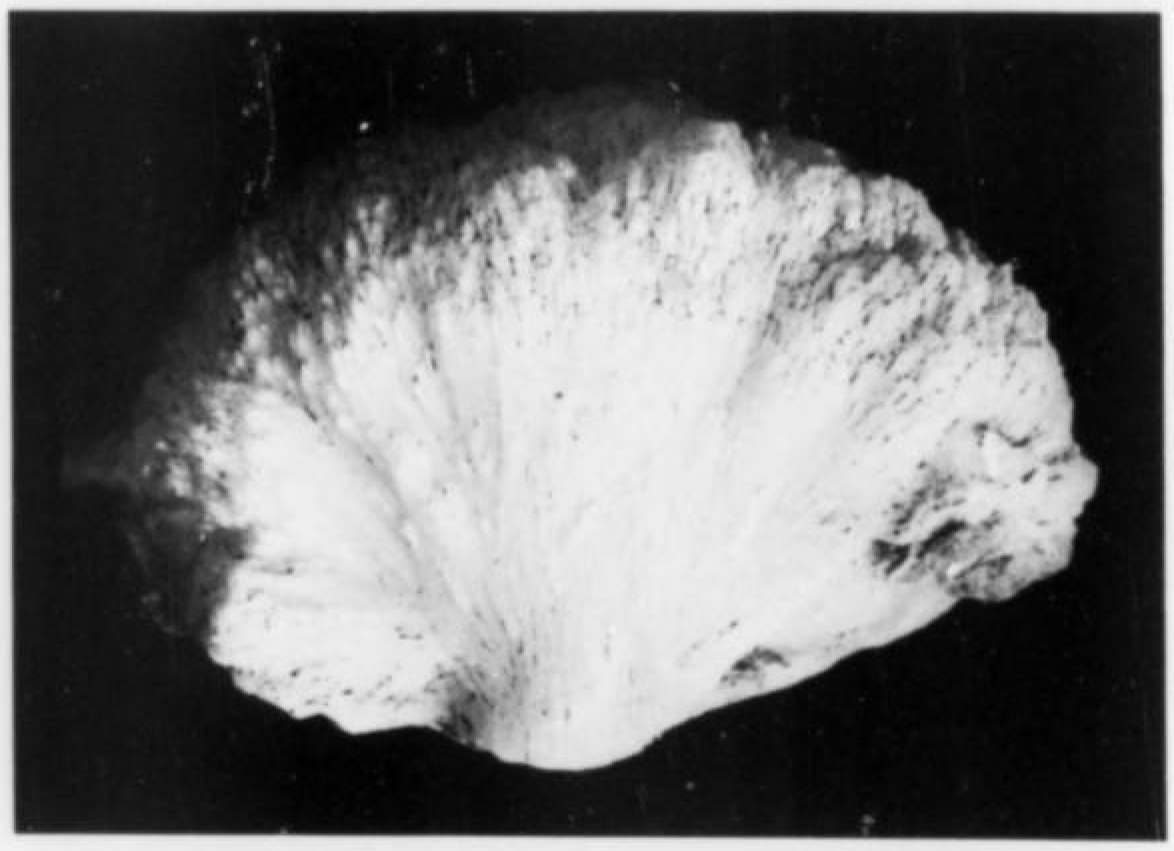

Figure 36. **An 8-cm specimen of white stilbite from Lidarhamar, Vagar Island, Faeroes.**

Stilbite

Stilbite is the most abundant of Icelandic zeolites, and occurs at many localities (loc. 1, 2, 3, 5, 9, 11, 12, 14, 15, 17), though attractive specimens are generally restricted to the tholeiites of eastern Iceland, as in the Breiðdalur-Berufjörður area. Most specimens in museums are from Teigarhorn, but fine specimens have occasionally been found at Búlandsdalur, Rauðafell, Ósfjall and Norðurdalur. Also remarkable are the stilbite specimens from Helgustaðanáma (loc. 11), white, opaque crystals averaging 2 or 3 cm in size, in cavities up to 1 m across; the crystals show {001}, {110} and {010}. Some specimens in museums have "bow-tie" formations up to 10 cm across. A few crystals also show {20$\bar{1}$}, and the smaller crystals having {001}, {110} and {20$\bar{1}$} exhibit a perfect pseudo-orthorhombic shape. At some localities (loc. 1, 15) stilbite forms radiating spherules and linings with {20$\bar{1}$} as the dominant or only form.

Stilbite crystals from the Faeroes show quite a different habit. Many reach about 1 cm in size, and are tabular on (010), with {110} and {001}. The colorless, transparent crystals show a six-sided outline and commonly an internal hour-glass structure. The larger tabular crystals have irregular terminations with numerous re-entrants (loc. 2, 5, 7, 9, 13, 16, 17).

Stilbite "bow-ties" occur at several localities too (loc. 4, 5, 6, 9, 10, 13, 14, 15, 17). Faeroes "bow-ties" have etched and rounded faces and indistinct edges in contrast to the well developed Icelandic examples. Crystals with {20$\bar{1}$} are uncommon, occurring only at locations 12, 15 and 19.

Thomsonite

Thomsonite is abundant in the analcime-thomsonite zone of the olivine basalts in eastern Iceland (Walker, 1960). It occurs as a white or yellowish lining in cavities, and also as radiating spherules to a few cm in diameter (loc. 10, 12, 14, 15). Crystal faces are rarely visible. Fan-shaped aggregates of bladed crystals have been found

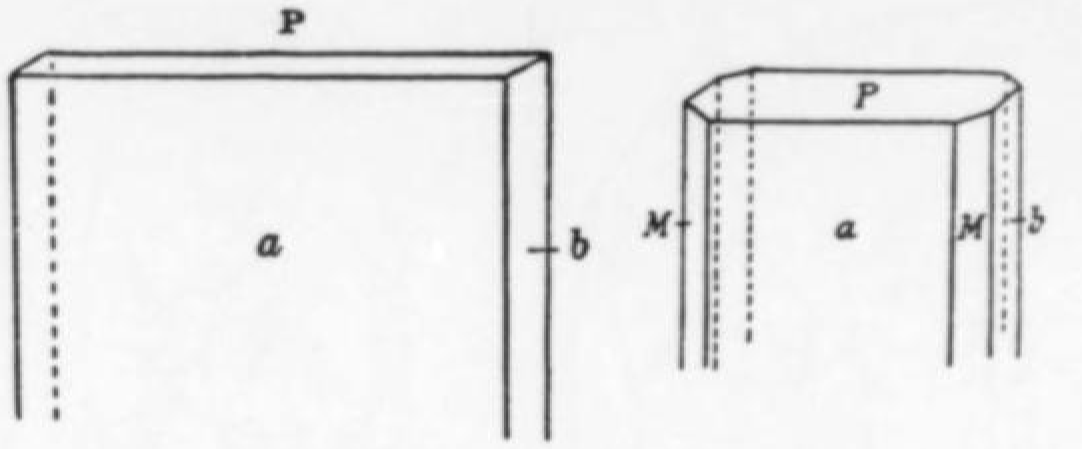

Figure 37. **Thomsonite crystal drawings (from Goldschmidt, 1922) based on crystals from the Faeroes.**

Figure 38. **Sheaves of orange-tipped white thomsonite crystals about 4 mm long, with mesolite and analcime, from Bulandstindur, Berufjörður, Iceland.**

at Búlandsdalur (loc. 15). Thomsonite has also been found in western Iceland, at locations 1 and 6 (Jakobsson, 1977; Hintze, 1897).

White crusts and radiating spherules of thomsonite (formerly called *faerolite*) to several cm in size are abundant and widely distributed in the Faeroes (loc. 1, 2, 4, 5, 8, 9, 11, 13, 14, 16). Faeroes specimens of thomsonite are usually larger and better than those from Iceland. Aggregates of bladed crystals have been found on Bordoy and Eysturoy Islands (loc. 2, 4). Thomsonite aggregates similar in appearance to *flos ferri* aragonite have been collected on Bordoy Island (loc. 2).

Other Zeolites

Other Icelandic zeolites mentioned by Jakobsson (1977) include natrolite from Brynjudalsvogur (in the southeastern part of the Hvalfjörður, loc. 1), erionite from Hofsá near Akureyri (loc. 9), and yugawaralite from Skálafellshnúta (loc. 16) and from Dorgeirsfell, Snaefellsnes. Walker (1960) also lists erionite from the Breiðdalur-Berufsjörður area.

NON-ZEOLITE MINERALS

Apophyllite

Attractive specimens of apophyllite consisting of white, transparent to translucent crystals reaching more than 3 cm in size and showing {110} and {101} have been found at Teigarhorn and are mostly in museum collections today. Similar specimens have been collected at Hvítarvík and Rauðafell in the Berufjörður (loc. 15), but not abundantly. Some of the Teigarhorn specimens in the Geological Museum, Copenhagen, show unusual faces which may be result of etching. Small pyramidal crystals have been found at Hvalfjörður (loc. 1), some having a pale green color. Columnar crystals with {001} occur at Heidarvatn (loc. 12).

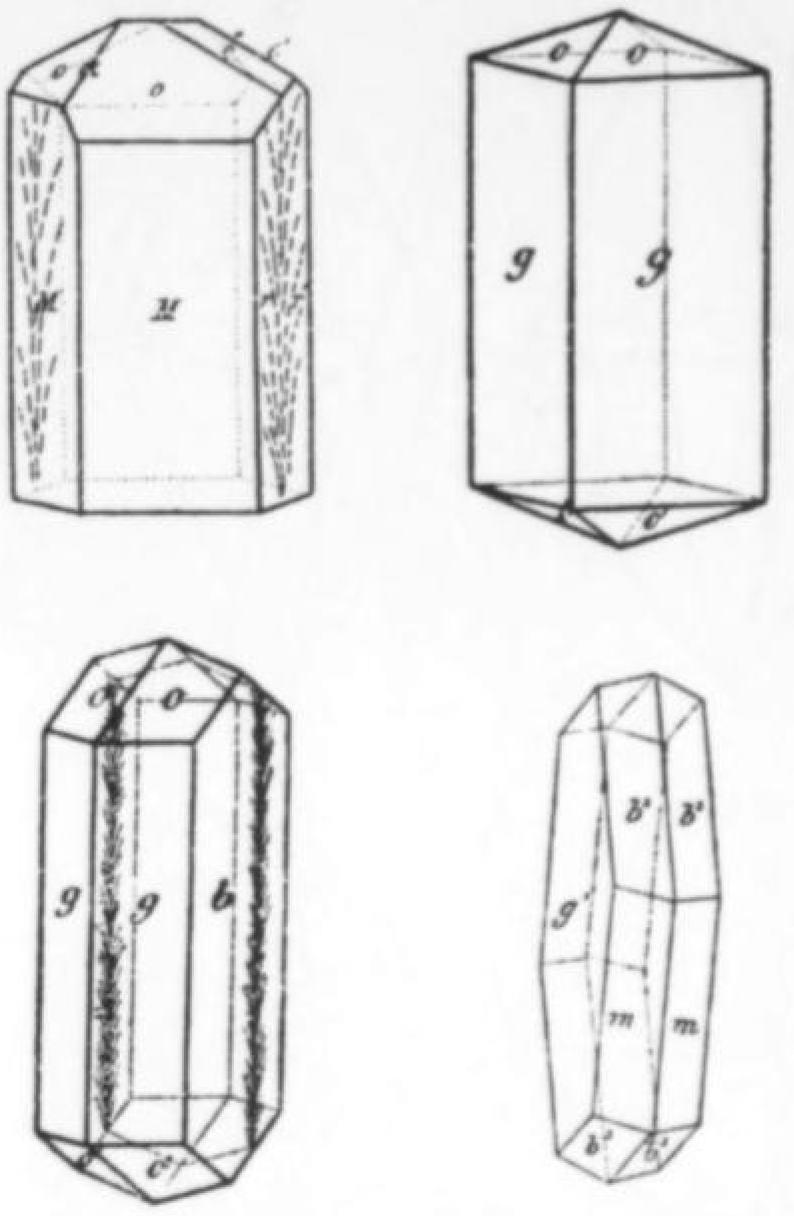

Figure 39. **Natrolite crystal drawings (from Goldschmidt, 1920) based on crystals from Iceland.**

Small, pyramidal crystals of apophyllite on petrified wood are known from Oxhaver Spring near Húsavik, Iceland (Hintze, 1897, p. 1741). These were originally called *oxhaverite* and *xylochlor*. Specimens have been preserved in the Royal Scottish Museum, Edinburgh, and in the U.S. National Museum (Smithsonian). The locality today is known as Uxhver and is located about 20 km south of Húsavík.

Figure 40. **Colorless apophyllite crystal 3 cm tall from Rauðafell, Berufjörður, Iceland.**

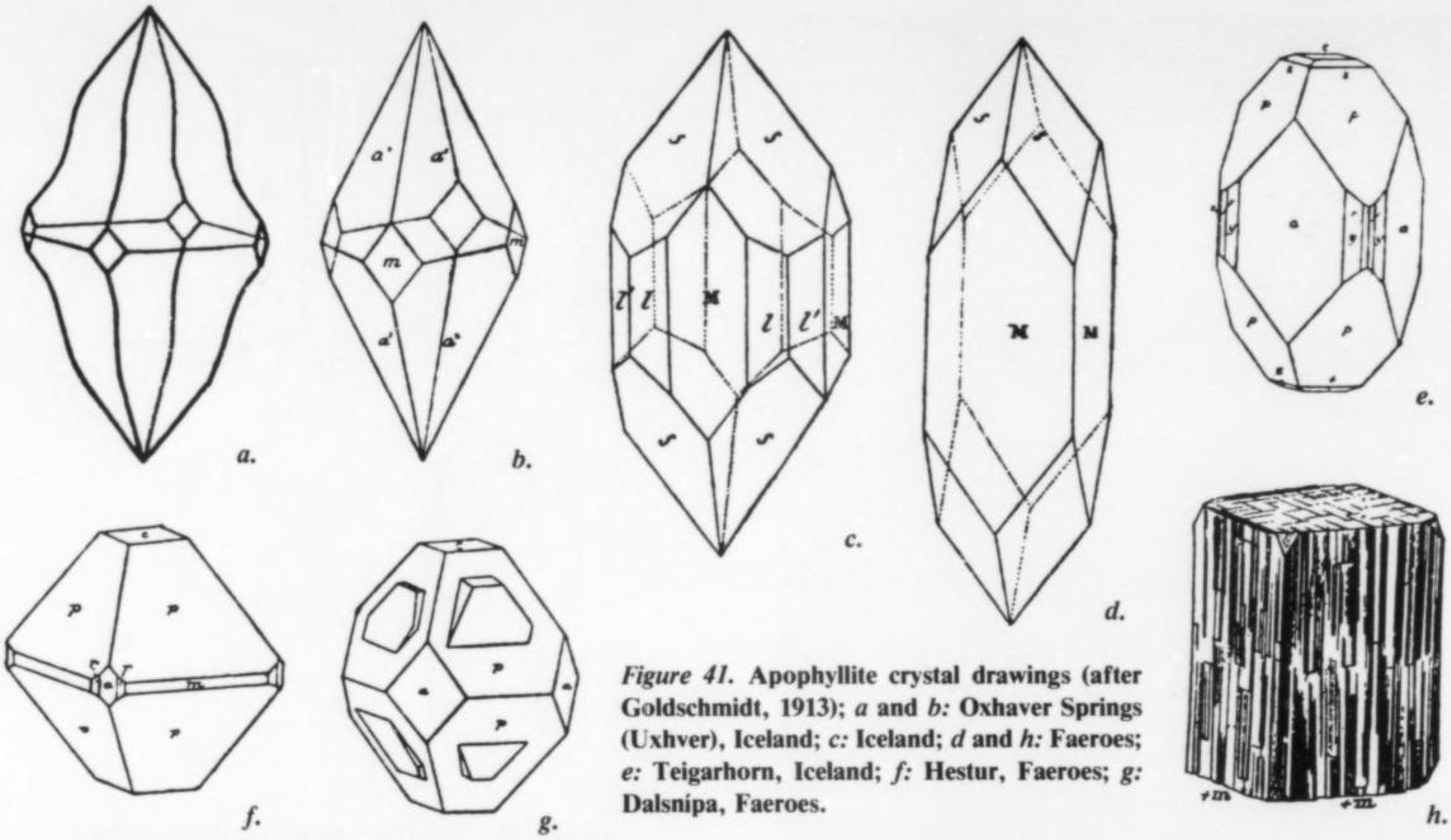

Figure 41. **Apophyllite crystal drawings (after Goldschmidt, 1913);** ***a*** **and** ***b:*** **Oxhaver Springs (Uxhver), Iceland;** ***c:*** **Iceland;** ***d*** **and** ***h:*** **Faeroes;** ***e:*** **Teigarhorn, Iceland;** ***f:*** **Hestur, Faeroes;** ***g:*** **Dalsnípa, Faeroes.**

Figure 42. **An interestingly terminated, colorless, 1-cm crystal of apophyllite from Teigarhorn, Berufjörður, Iceland; an old specimen in the Mineralogical Museum, Copenhagen.**

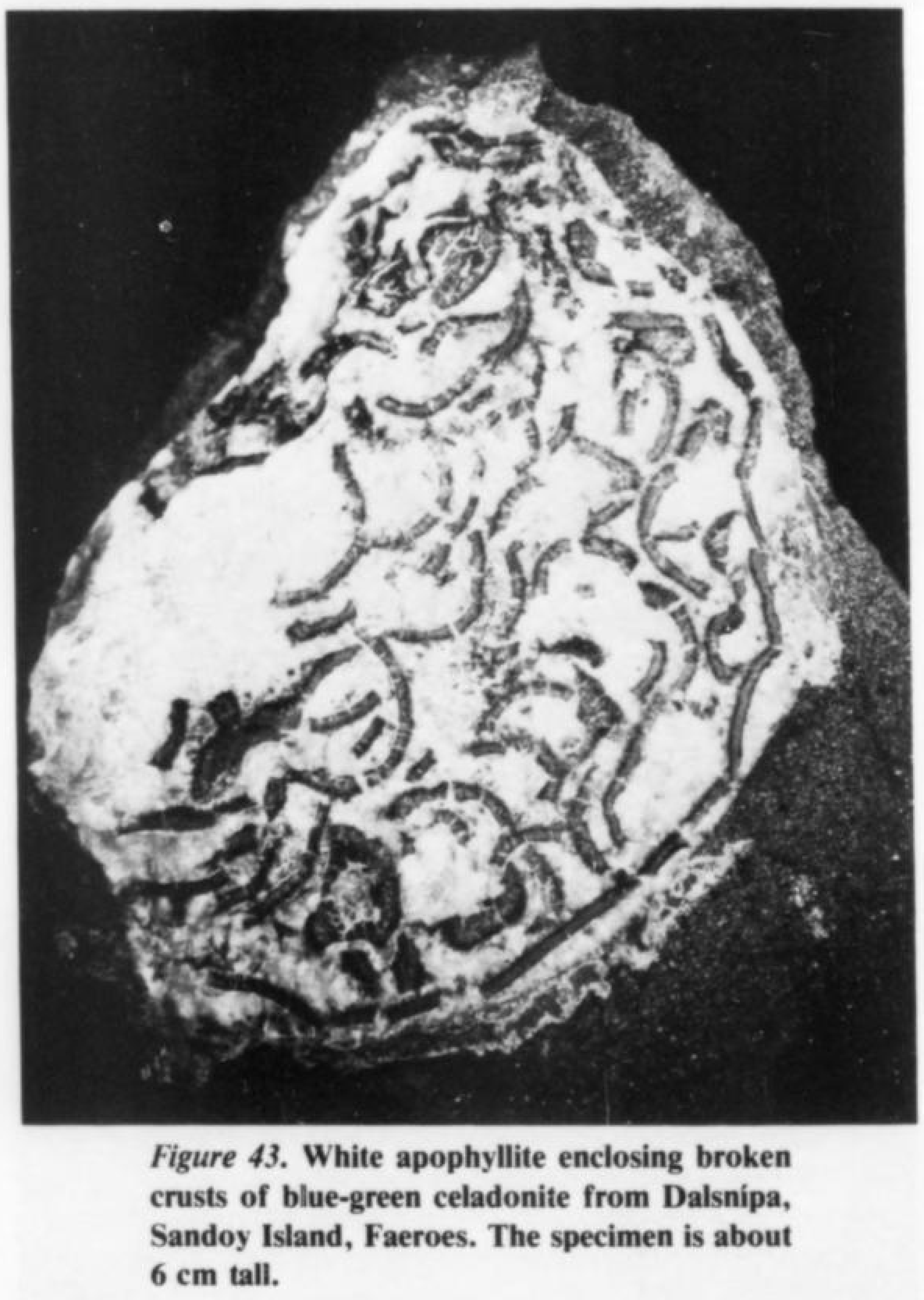

Figure 43. **White apophyllite enclosing broken crusts of blue-green celadonite from Dalsnípa, Sandoy Island, Faeroes. The specimen is about 6 cm tall.**

Specimens of pyramidal apophyllite crystals showing {110}, {101} and {001} have been found at several Faeroes localities (loc. 2, 5, 6, 9, 12, 18); some of these are very attractive. Apophyllite here is generally colorless to white and opaque to translucent, though pink-colored specimens have been found (loc. 6, 18).

Prismatic crystals 2 by 15 mm have been collected on Nólsoy Island (loc. 16) and also near Haldarsvík (loc. 10). Thick, tabular crystals with {001} dominant have been found in association with gyrolite and thomsonite (loc. 4, 11). Deep green but poorly crystallized apophyllite has been found at location 14. In general, apophyllite is much more abundant in the Faeroes than in Iceland.

Calcite

Calcite occurs in association with zeolites at most Icelandic localities (loc. 1, 3, 5, 7, 9, 10, 11, 12, 14, 15, 17). Crystals vary in habit from tabular to scalenohedral and rhombohedral, and appear to have crystallized both earlier and later than the associated zeolites.

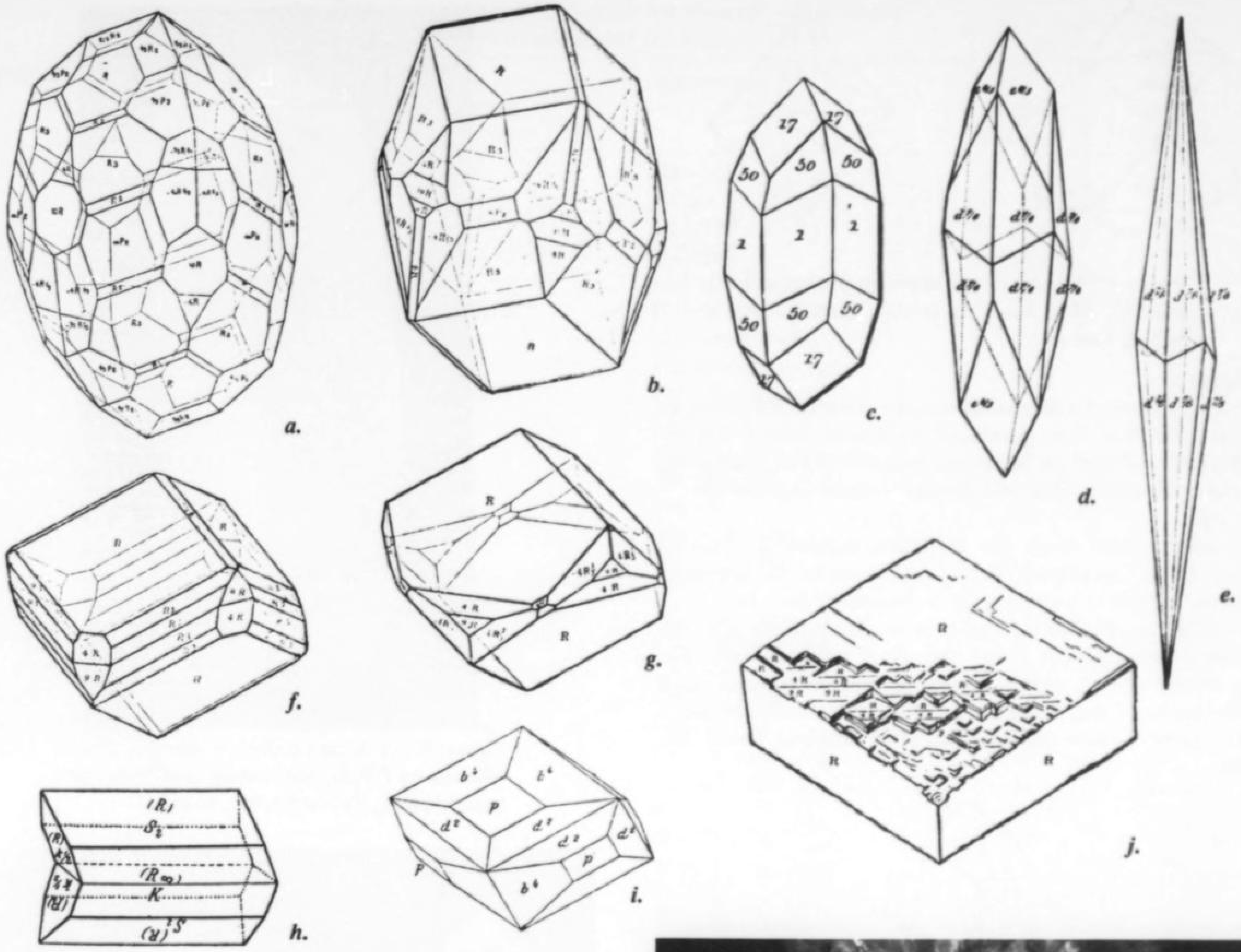

Figure 44. **Calcite crystal drawings (from Goldschmidt, 1913);** ***a, b, f, g*** **and** ***j:*** **Reyðarfjörður, Iceland;** ***c:*** **Faeroes;** ***d*** **and** ***e:*** **Fugloy, Faeroes;** ***h:*** **Vágar, Faeroes;** ***i:*** **Iceland.**

Figure 45. **A 2-cm crystal of colorless calcite from Gásafelli, Vagar Island, Faeroes.**

Figure 46. **A 2-cm rhombohedral crystal of yellowish calcite from Djupifjörður, Breiðafjörður, Iceland.**

The famous Iceland spar locality at Helgustadanáma (loc. 11) produced very large crystals, some more than half a meter in size, having a combination of scalenohedral and rhombohedral forms. Transparent pieces suitable for optical uses sold for about $1 per ounce in 1890, when they were being found at Eskifjörður (Gratacap, 1907).

Calcite also occurs with zeolites in the Faeroes (loc. 2, 5, 6, 8, 13), where it usually forms rhombohedrons or, less commonly, scalenohedral-rhombohedral combinations as have been found in a calcite vein near the road at Vágar (loc. 17).

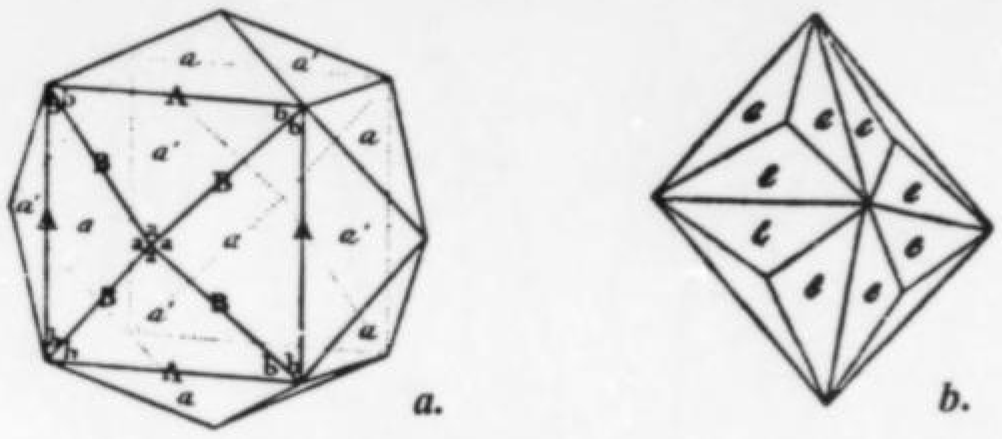

Figure 47. **Copper crystal drawings (from Goldschmidt, 1918) based on crystals from Nolsoy Island, Faeroes.**

Copper

Copper associated with zeolites occurs at several localities in the Faeroes, and was first mentioned by Cornu (1907). Cornu's material was collected on Suderoy Island (loc. 20) as small grains and plates in cavities filled with fibrous scolecite and mesolite.

Gyrolite

Gyrolite is listed from the Breiðdalur-Berufjörður area by Walker (1960). The author collected a specimen having aggregates of tabular crystals to 1 cm near Ós at Breiðdalur (loc. 14).

In the Faeroes, gyrolite is found to be locally abundant in a roadcut near Ljósá, Eysturoy Island (loc. 4). It occurs as very thin, clear, tabular crystals with hexagonal or irregular outlines, some crystals reaching 5 mm in size and situated on layers of thomsonite. Similar specimens have also been found on Streymoy Island (loc. 11, 13).

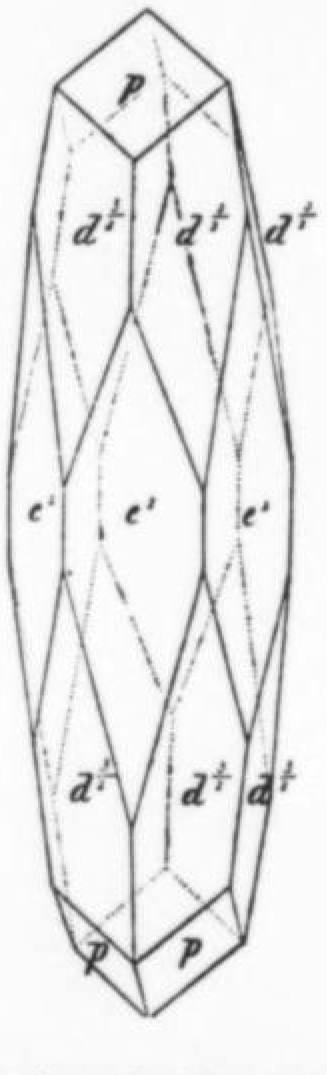

Figure 48. **Drawing of a Faeroes quartz crystal (from Goldschmidt, 1922).**

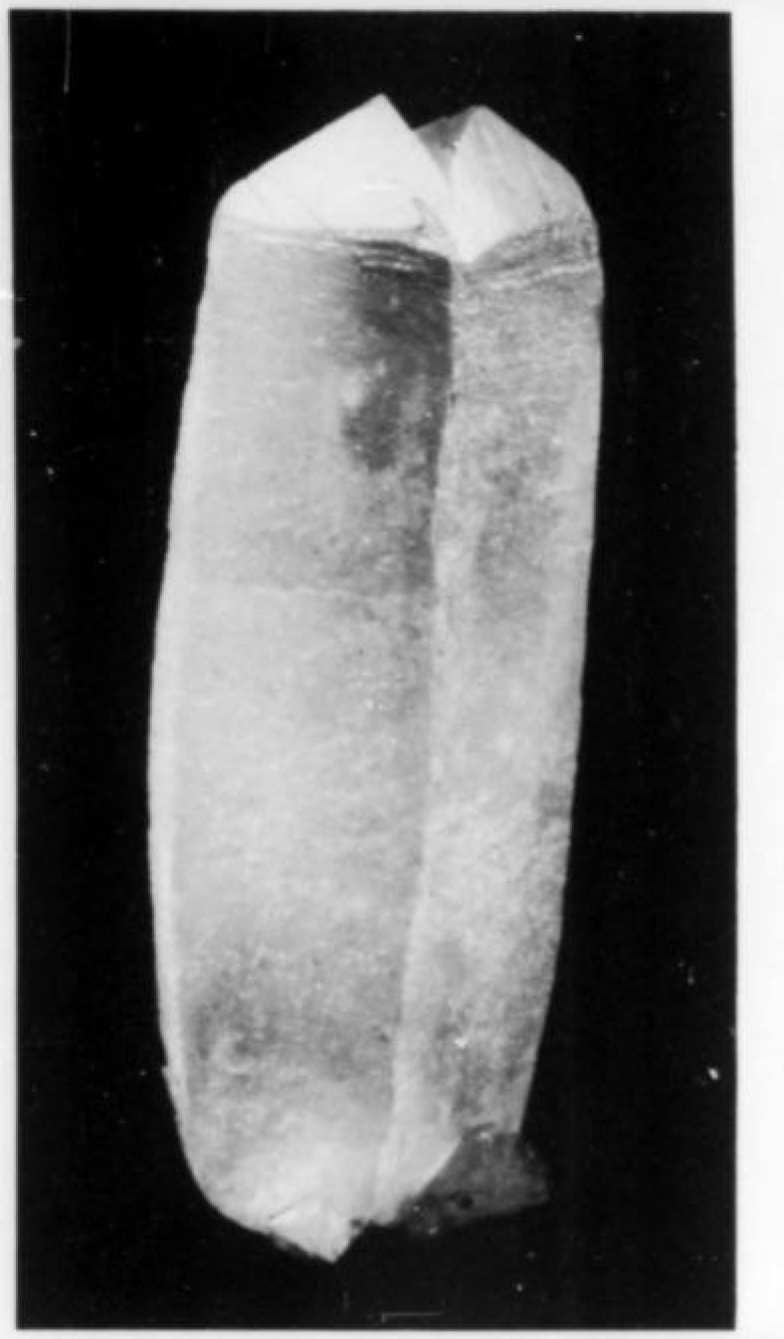

Figure 49. **A 3-cm crystal of colorless quartz twinned on ($10\bar{1}0$) (Schneeberg law) from Helgustaðanáma, Reyðarfjörður, Iceland.**

Figure 50. **Several colorless quartz crystals to 3 cm, with white stilbite and laumontite, from Helgustaðanáma, Reyðarfjörður, Iceland.**

Quartz and Opal

Geodes lined with typical, rhombohedrally terminated quartz crystals are abundant in the Breiðdalur-Berufjörður area (loc. 14, 15). The crystals are milky and not particularly attractive. Some specimens have a pale amethyst color are in the Petra Sveinsdottir collection (loc. 13) (Betz, 1974a). Crystals twinned on $\{10\bar{1}0\}$, according to the Schneeberg law, are also known (Strunz, private communication).

The cryptocrystalline varieties jasper, chalcedony and agate occur in the eastern fjordlands of Iceland, as does the species opal. Fine specimens are occasionally found in boulders, and several examples are preserved in the Sveinsdottir collection. Chalcedony was one of the first minerals to be described from the Faeroes (Cappel, 1781), and many localities are given by Currie (1907). Gem opal has been found in the Faeroes too, as reported by Bedemar (1822).

Others

A number of other species including aragonite, celadonite, chlorite, epidote and okenite have been reported.

CRYSTALLIZATION SEQUENCES

In many cavities one might encounter in Iceland and the Faeroes, there will be only one species present, or none at all. But numerous assemblages have also been found, and these each reveal the succession of crystallization, if studied carefully. Listed in Table 2 are some of the successions observed by the author. Naturally this list cannot pretend to be complete in any way, but it does show an interesting variety of sequences.

Table 2. **Sequences of crystallization observed on specimens from Iceland and the Faeroes.**

Succession	Loc. number (Iceland)	Loc. number (Faeroes)	Succession	Loc. number (Iceland)	Loc. number (Faeroes)
An→Ap*		4	He→Me	1	
An→Ch		4	He,Me→La,St→La		13
An→La		4	He→Me→St→Ap		10
An→Le	4		He→Sc	14,15	
An→Ph,Ch	8		He→St	1,12,14,15	6,15
An→Th		4,13	He→St→Ap		7,17
An→Th→Ch	8		He→St→Ca→La	17	
An→Th→Me	15		He→St→Ch	1	
Ap→Ch		12	He→Th→Me→St		2,5
Ca→Ch→Gi→Th	10		La→St,La		17
Ca→He→Ca	15		Me,An	15	
Ca→Me→An	12		Me→Ap→St		7
Ca→Qu→Ep	15		Me→St	15	
Ca→Qu→St	3		Mo→Ap→Ca		19
Ca→Mo→Ep→He→Ch	15		Mo→Ep→He	15	
Ca→St	11		Mo→He	15	
Ca→St→Ca	5		Mo→St→He		19
Ca→Th		2	Qu→Ep→Ch→La	9	
Ca→Th→Ap	12		Qu→He	12	
Ch→An	12		Qu→La→Ca	7	
Ch→Ap		14	Qu→St→Ca	3	
Ch→Ca		2	Qu→St→He→Ap	15	
Ch→Gi→Th	10		Qu→St→He→Ca→La	11	
Ch→He		10	St→Ap	1	
Ch→St	12	2,8,14	St→Ca→La	17	
Ch→Th→Ap	12		St→Ch		19
Cu→Sc,Me		20	St→Me	1	
Ep→He	15		Th→Ap	12	16
Gy→Sc→Ap	14		Th→Ap→La		13
He→Ap→Ch		6,9,13	Th→Gy		13
He→Ch→St		2,9	Th→Gy→Ap		4,10,13
He,Ch,Th		2	Th→Gy→Le→Me		11
He→Le	1		Th→St	12	16

*Mineral name abbreviations:
An — analcime
Ap — apophyllite
Ca — calcite
Ch — chabazite
Ep — epistilbite
Gi — gismondine
He — heulandite
La — laumontite
Le — levyne
Me — mesolite
Mo — mordenite
Ph — phillipsite
Sc — scolecite
St — stilbite
Th — thomsonite

ACKNOWLEDGMENTS

The author is indebted to Anne-Liese Thomasen, archivist at the Geological Museum, Copenhagen, for her interest and generous assistance with many of the old papers, letters and references, and especially for her translation of the Olavius letter. Ole V. Petersen, curator at the same institution, kindly made available for study the portion of their collection which is not on public display. Brian Jackson of the Royal Scottish Museum, Edinburgh, provided information on Icelandic specimens and also supplied a copy of the Currie (1907) paper. For mineral identifications I wish to thank Gerhard Hentschel, Wiesbaden; and my friend Klaus Petitjean, Worms, I thank for his valuable company on several excursions.

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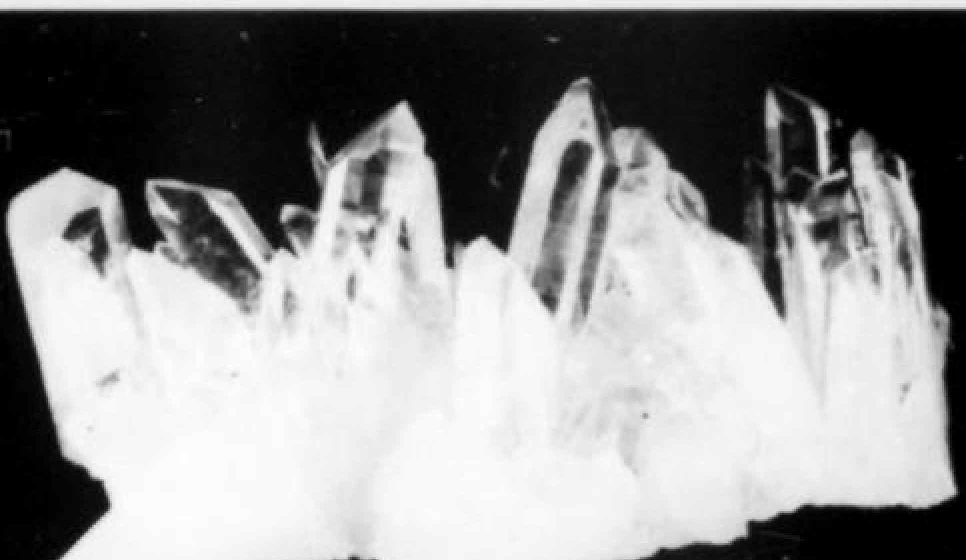

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Zeolites
in Yellowstone National Park

by **Keith E. Bargar, Melvin H. Beeson,** and **Terry E. C. Keith**
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Scanning electron microscope studies have revealed details of the morphology and paragenesis of several zeolites, and associated hydrothermal alteration minerals, in drill cores from hot spring and geyser areas of Yellowstone National Park. Minerals found include clinoptilolite, mordenite, analcime, laumontite, intermediate heulandite, dachiardite, yugawaralite, erionite, wairakite, heulandite, stilbite (?), gyrolite, okenite, pectolite, and truscottite.

INTRODUCTION

During 1967 and 1968, the U.S. Geological Survey completed 13 research diamond drill holes in hot spring and geyser areas of Yellowstone National Park, Wyoming, to obtain detailed physical and chemical data from the shallow part of a high-temperature geothermal system (White *et al.*, 1975). Cores from the 13 drill holes were studied in detail to determine the hydrothermal mineral phases present. In addition, cores from two drill holes (C-I and C-II), drilled by the Carnegie Institution of Washington in 1929 and described by Fenner (1936), are being restudied (see Fig. 1 for location of all drill holes).

The 15 drill holes ranged in depth from about 65 to 330 m and averaged 150 m. Maximum temperatures varied from 143.1°C in drill hole Y-7 to 237.5°C in drill hole Y-12, the deepest hole (White *et al.*, 1975). Nearly continuous core shows that the drill holes typically penetrate one or more of the following rock units: (1) relatively thin layers of opaline sinter deposited at the surface by thermal waters; (2) variable thicknesses of hydrothermally altered and cemented sediments accumulated during the Pinedale glaciation (about 50,000 to 10,000 years ago; Pierce *et al.*, 1976); and (3) hydrothermally altered rhyolitic flows and related pyroclastic rocks of middle and late Pleistocene age (Christiansen and Blank, 1972).

Details of hydrothermal alteration studies were previously reported for drill holes C-I and C-II (Fenner, 1936), Y-1 (Honda and Muffler, 1970; Honda and Sasaki, 1977), Y-3 (Barger *et al.*, 1973), Y-5 (Keith and Muffler, 1978), Y-7 and Y-8 (Keith *et al.*, 1978b), Y-11 (Muffler and Bargar, 1974), and Y-13 (Keith *et al.*, 1978a). Most cores were hydrothermally altered to varying degrees by dilute, upflowing thermal waters. Glass, in the form of obsidian grains in the glacial sediments and glassy parts of the rhyolitic flows, is readily altered to clay and zeolite minerals. Typically, clay is deposited along concentric shell-like hydration cracks in the glass (Fig. 2) so that the perlitic texture is preserved. Subsequently, zeolites and later clay minerals replaced the glass (Figs. 3, 4, and 5). Zeolite and clay minerals, along with several other hydrothermal silica, mica, carbonate, sulfide, oxide, feldspar and calcium silicate-hydrate minerals, were also deposited on the walls of cavities and as fracture and vein fillings by the circulating hot waters.

The Yellowstone drill cores have been systematically studied by thin-section, X-ray diffraction, electron microprobe and scanning electron microscope (SEM) methods. SEM photographs of numerous hydrothermal minerals were obtained using a Cambridge Stereoscan 180[1] SEM equipped with energy-dispersive X-ray analysis (EDAX) capabilities. The SEM provides useful information on the morphology, chemistry, and paragenesis of the hydrothermal minerals.

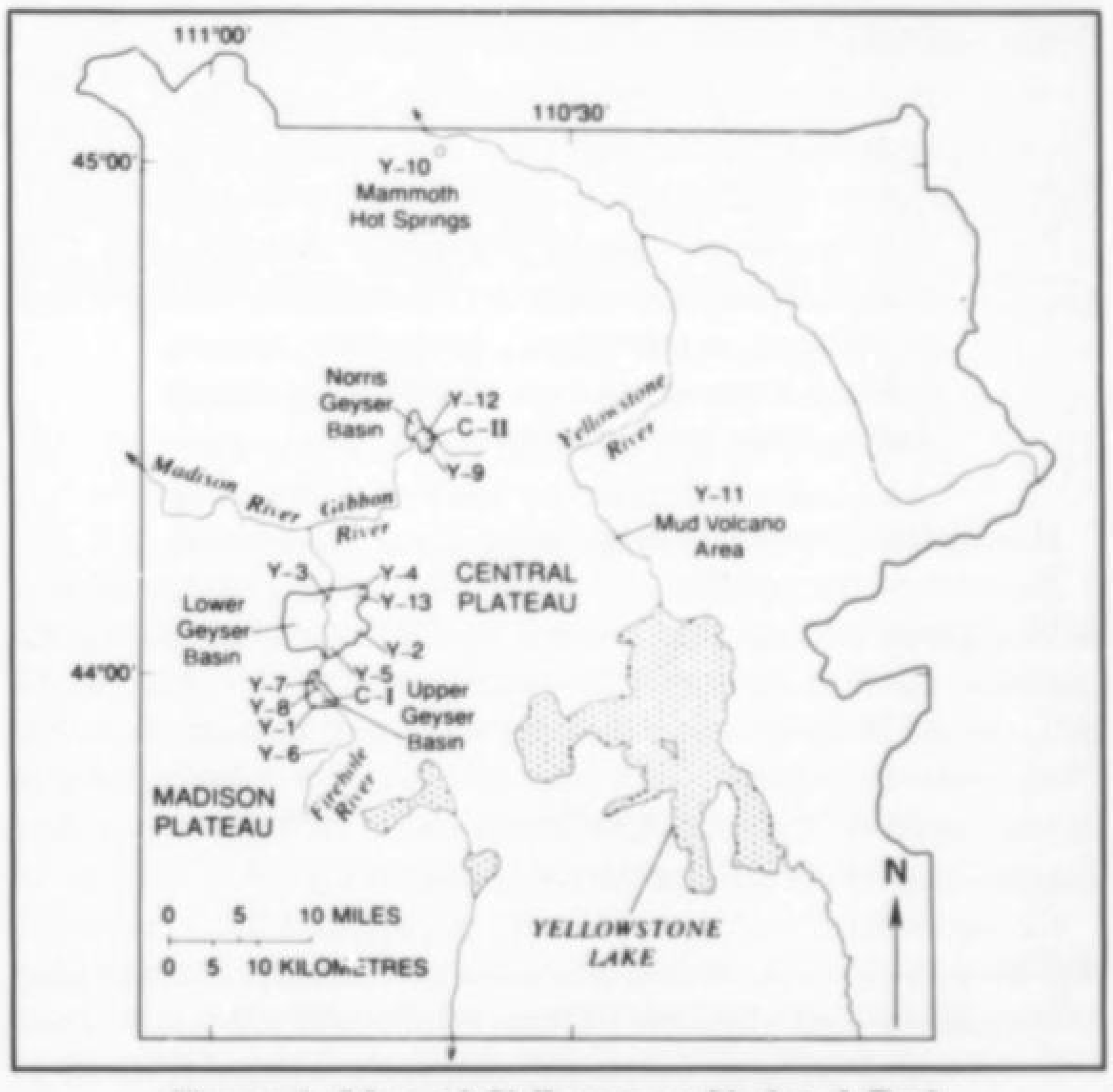

Figure 1. **Map of Yellowstone National Park showing location of research drill holes.**

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[1] Any use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

ZEOLITE MINERALS

Clinoptilolite and mordenite are the two most abundant zeolites in the Yellowstone drill cores. Other zeolites in approximate decreasing order of abundance, are: analcime, laumontite, intermediate heulandite, dachiardite, yugawaralite, erionite, wairakite, heulandite and stilbite (?). Included with the zeolite minerals in this report are three calcium silicate-hydrate minerals: gyrolite, okenite, and truscottite, as well as pectolite, a mineral related to the calcium silicate-hydrates (Heller and Taylor, 1956). Calcium silicate-hydrate minerals, which are chemically similar to some calcium zeolites (except for aluminum), are frequently associated with zeolites in hydrothermal environments but are generally less abundant.

The distribution of a few zeolite minerals, such as erionite, may be temperature related; however, the most important factor controlling the formation of zeolites in the Yellowstone drill cores is the chemistry of the thermal waters and the rocks through which these waters flow. In general, both rocks and waters are poor in calcium and rich in sodium and potassium (Hamilton, 1963; Rowe *et al.*, 1973), so that conditions generally favor the deposition of sodium and potassium minerals.

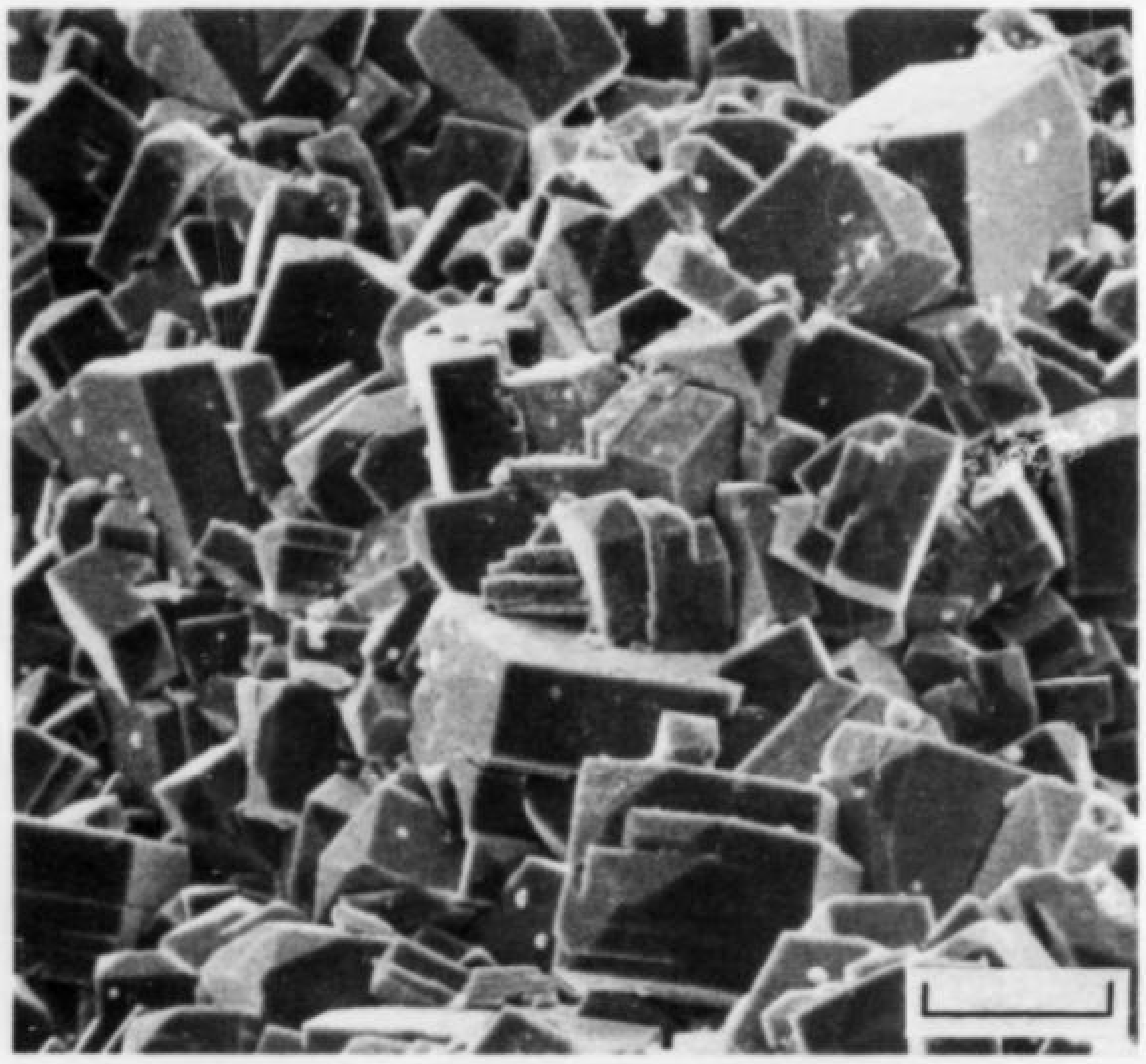

Figure 2. **Photomicrograph of altered glass from $\sim$14 m in drill hole Y-2 (plane light). Perlitic texture is preserved by deposition of montmorillonite along concentric hydration cracks. Subsequent alteration consists of blocky or tabular intermediate heulandite crystals oriented perpendicular to clay-filled hydration cracks. Scale bar is 50 microns.**

Figure 3. **Scanning electron micrograph of altered core from $\sim$14 m in drill hole Y-2. One montmorillonite-filled shell-like hydration crack is shown in the left half of the figure. Right half of figure shows the area between clay-filled hydration cracks in which tabular intermediate heulandite crystals are oriented perpendicular to cracks. Fibrous mordenite and spherical or hemispherical clusters of montmorillonite platelets are later than the intermediate heulandite (see Fig. 9). Scale bar is 10 microns.**

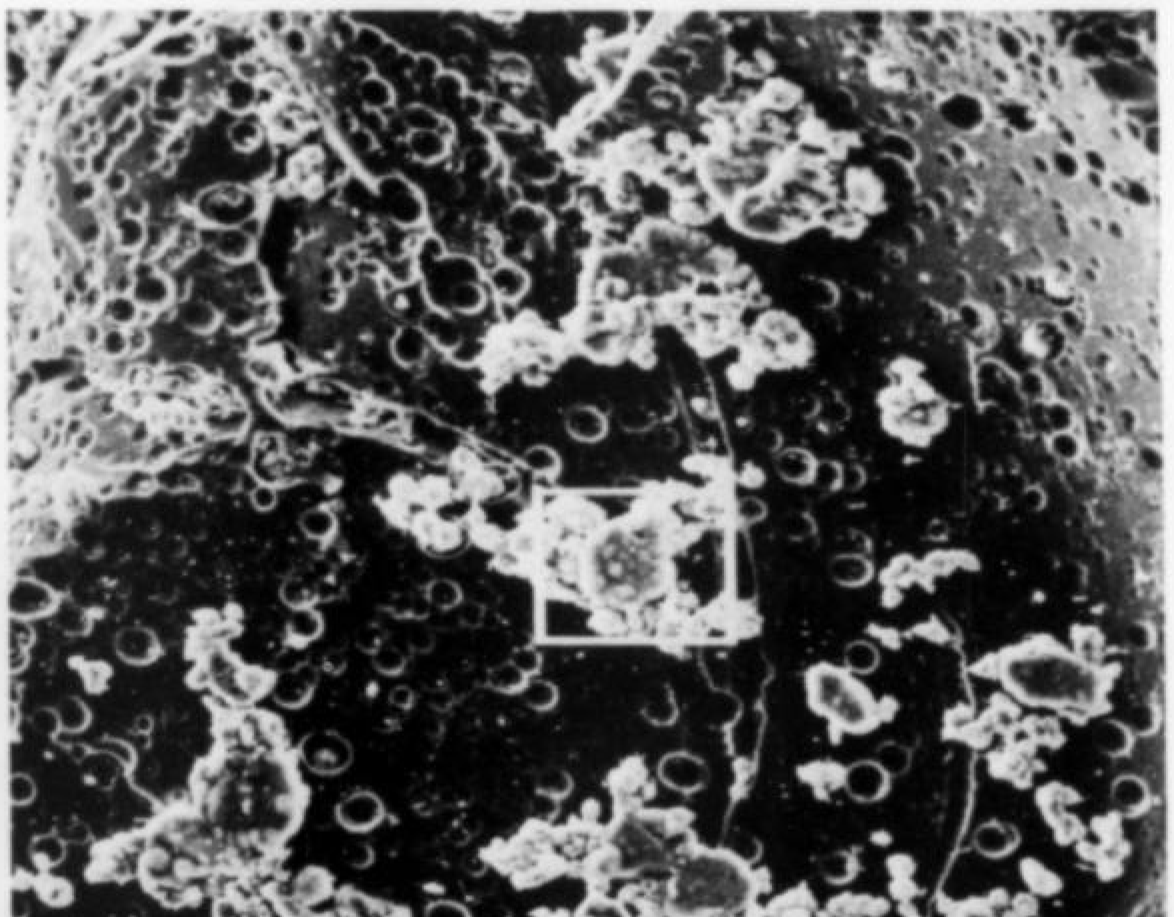

Figure 4. **Scanning electron micrograph of altered glassy rhyolite from $\sim$140 m in drill hole Y-2. Remnant perlitic texture is preserved by feathery clusters of intergrown short mordenite fibers generally oriented with their long axes perpendicular to former hydration cracks. X-ray diffraction also indicates the presence of illite. Scale bar is 30 microns.**

Heulandite-Group Minerals

Because of the similarity in X-ray diffraction patterns of heulandite group minerals, the thermal stability of these minerals was routinely checked by overnight heating of the samples at 450°C (Mumpton, 1960). Samples showing no change in intensity or displacement of the (020) X-ray peak at about 8.9 Å in response to heating (as was the case for the majority of Yellowstone core samples studied), were classified as clinoptilolite.

Clinoptilolite [$(\mathrm{Na,K,Ca})_{2\text{-}3}\mathrm{Al}_3\ (\mathrm{Al,Si})_2\mathrm{Si}_{13}\mathrm{O}_{36}\cdot 12\mathrm{H}_2\mathrm{O}$] occurs in 9 of the cores studied, usually as a major alteration product of glass and as cavity and fracture fillings. Clinoptilolite crystals in the Yellowstone drill cores commonly display a blocky (Fig. 6) or tabular (Fig. 7) habit, although a relatively unaltered obsidian grain (Figs. 8 and 9) exhibited rosettes of bladed clinoptilolite crystals and a platy boxwork of montmorillonite deposited along perlitic cracks and in shallow solution pits.

A single sample from drill hole Y-6 (Fig. 10) showed a con-

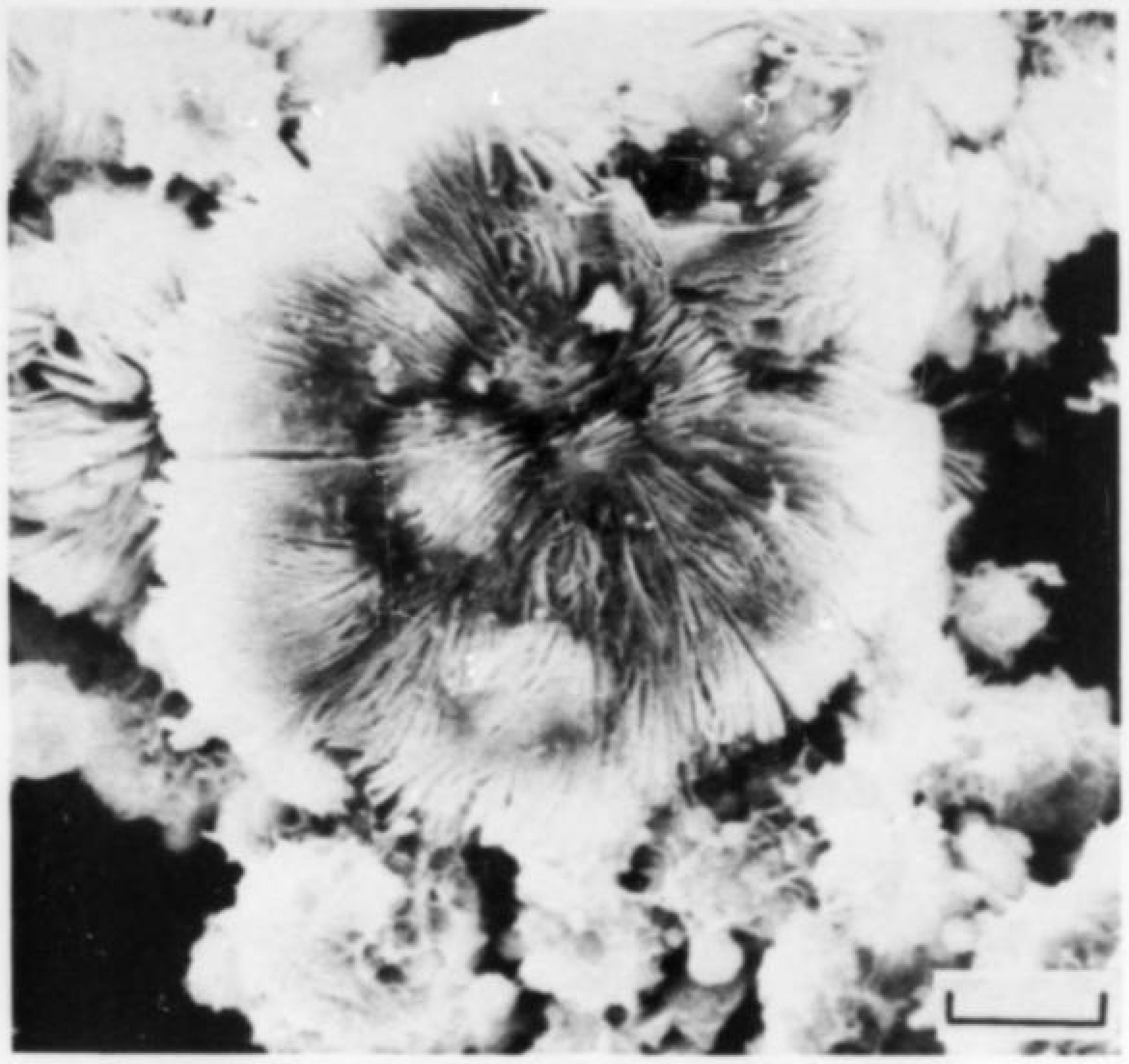

Figure 5. **Scanning electron micrograph showing a detailed paragenetic sequence of hydrothermal minerals from 14 m in drill hole Y-2. Intermediate heulandite crystals are partly coated by mordenite fibers (upper right-hand corner) and spherical or hemispherical aggregates of montmorillonite platelets. Scale bar is 1 micron.**

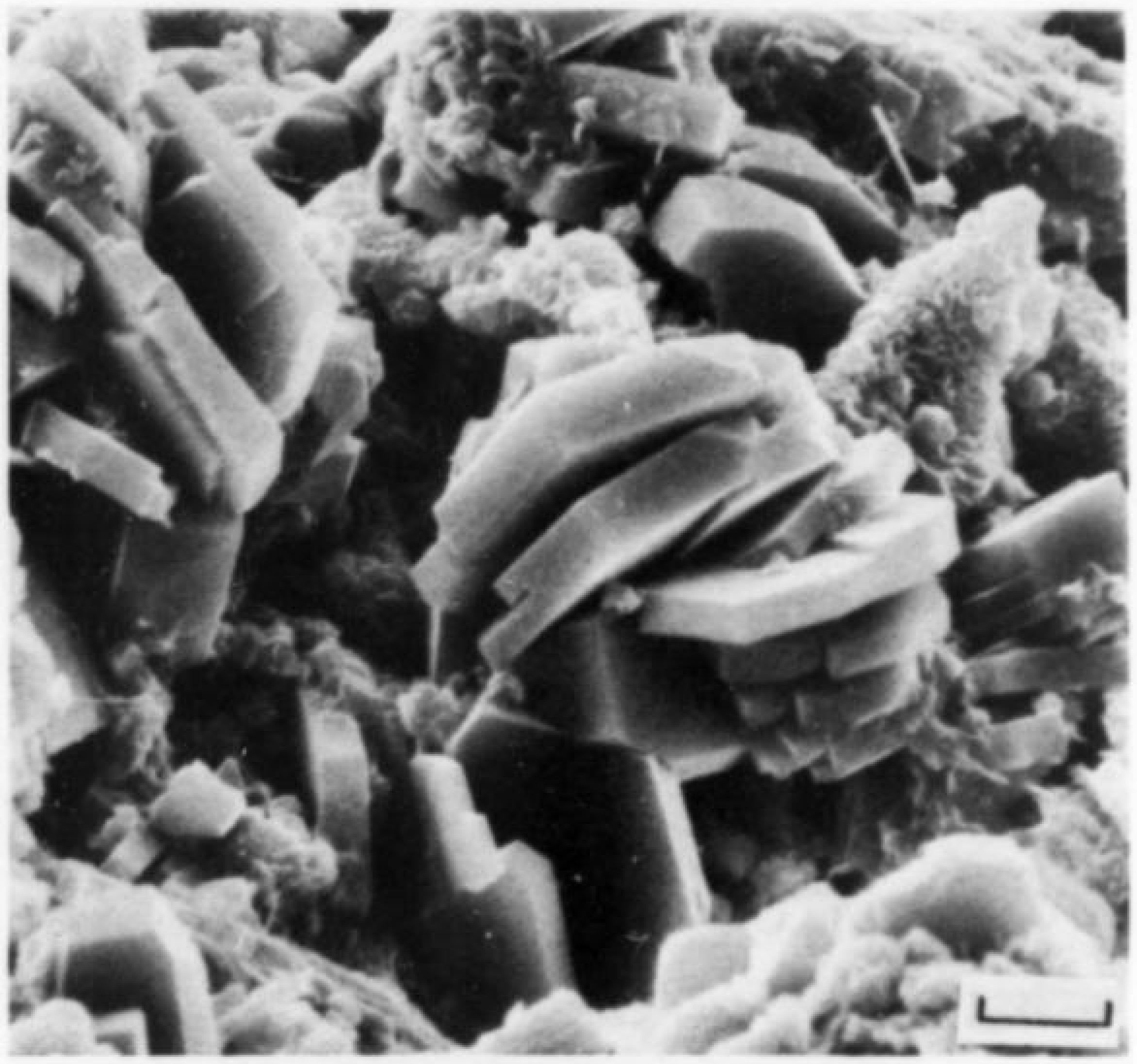

Figure 6. **Scanning electron micrograph of intergrown blocky clinoptilolite crystals from ~27 m in drill hole Y-2. The few tiny white hemispherical concentrations are montmorillonite crystals deposited later than the clinoptilolite. Scale bar is 50 microns.**

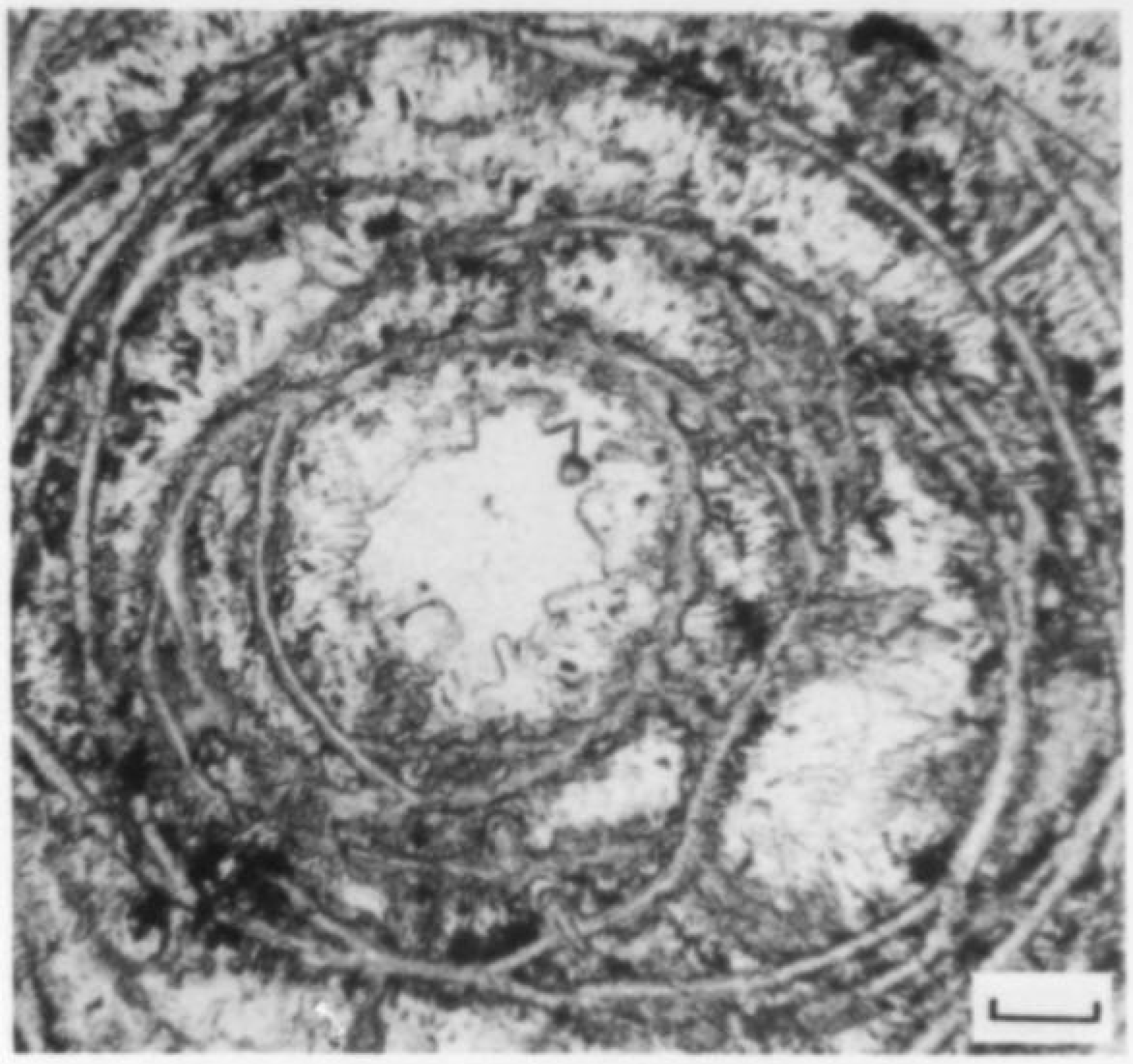

Figure 7. **Scanning electron micrograph showing intergrown tabular clinoptilolite crystals from ~14 m in drill hole Y-3. Scale bar is 5 microns.**

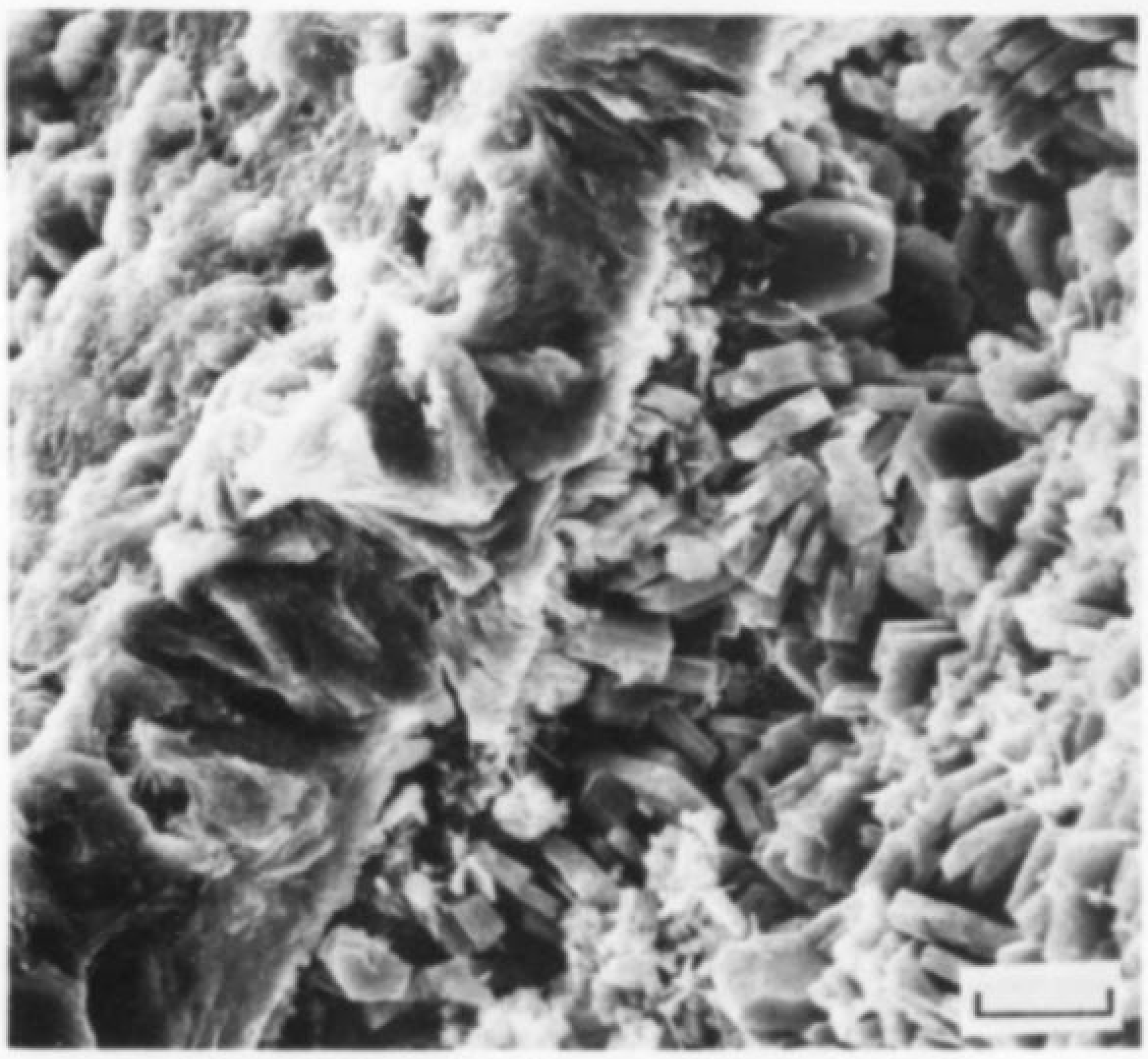

Figure 8. **Scanning electron micrograph of obsidian grain from ~26 m in drill hole Y-2. Perlitic cracks and shallow solution pits in the grain are partly filled by clinoptilolite and montmorillonite. Scale bar is 30 microns.**

siderable decrease in intensity and displacement of the (020) peak to about 8.3 Å after heat treatment. The tabular zeolite crystals were therefore classified as heulandite [$(Na,Ca)_{4-6}Al_6(Al,Si)_4Si_{26}O_{72} \cdot 24H_2O$] (the structure was completely destroyed by heating at 550°C).

Several samples from drill hole Y-2 showed a marked decrease in the intensity of the (020) peak at 8.9 Å with the appearance of additional reflections near 8.3 Å, and occasionally at about 8.7 Å, after heating. Such thermal behavior is similar to the behavior of the intermediate or heulandite type 2 phase described by Alietti (1972) and Boles (1972). Intermediate heulandite, found only in core from drill hole Y-2, occurs intermittently to a depth of 56 m. This mineral appears as an alteration of glass and as open-space cavity and fracture fillings, similar to clinoptilolite, and displays tabular or blocky crystal habits much like clinoptilolite (see Figs. 2, 3, and 5).

Twenty-six heulandite-group zeolites from the Yellowstone drill cores were analyzed with an electron microprobe, including six intermediate heulandites from drill hole Y-2. The remainder were clinoptilolites from drill holes Y-2, Y-7, and Y-8. A ternary plot of the silicon/aluminum ratio (Si/Al), sum of divalent cations

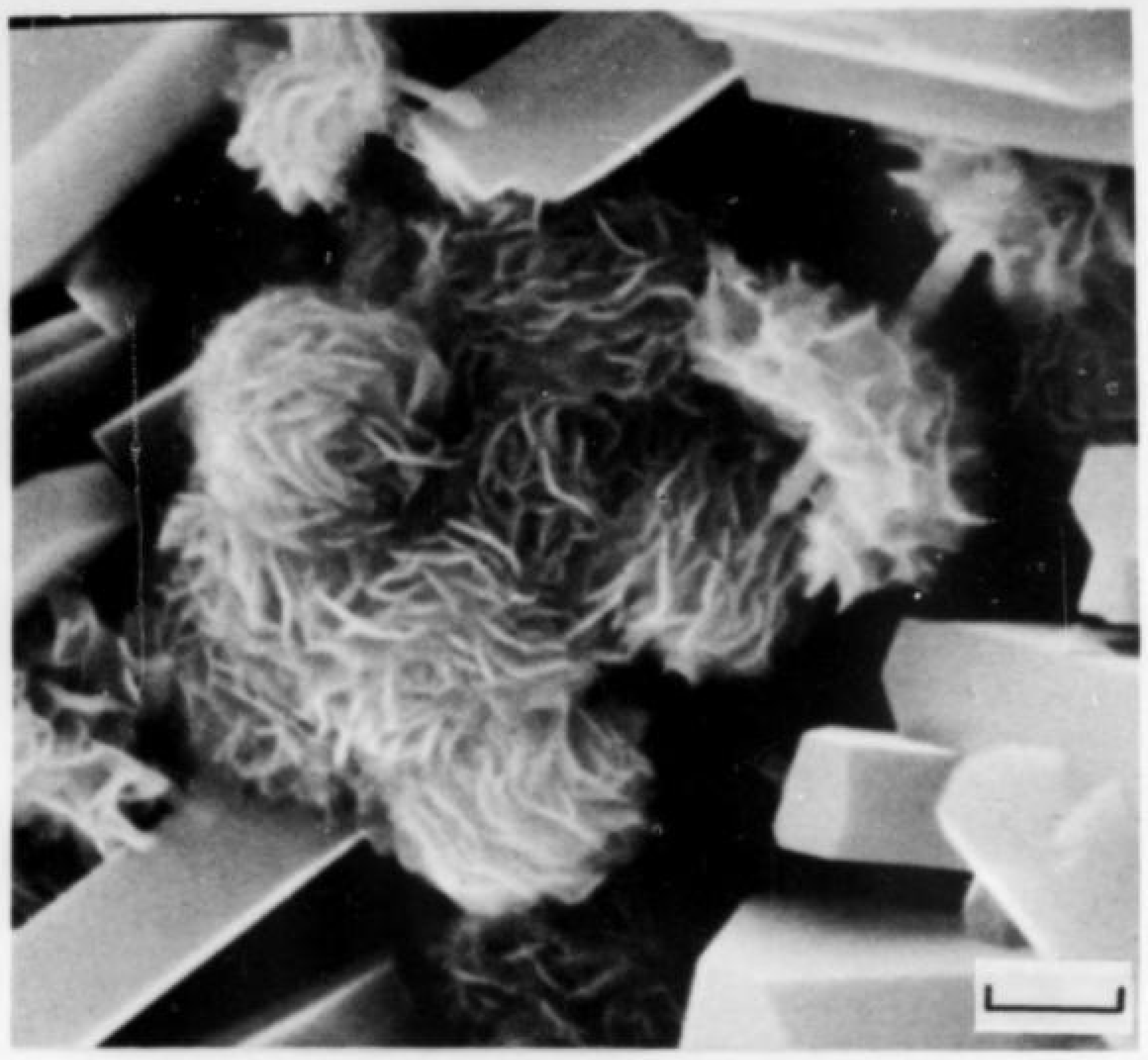

Figure 9. **Scanning electron micrograph of the inset part of Figure 8, showing a bladed clinoptilolite rosette and boxwork of montmorillonite. Scale bar is 5 microns.**

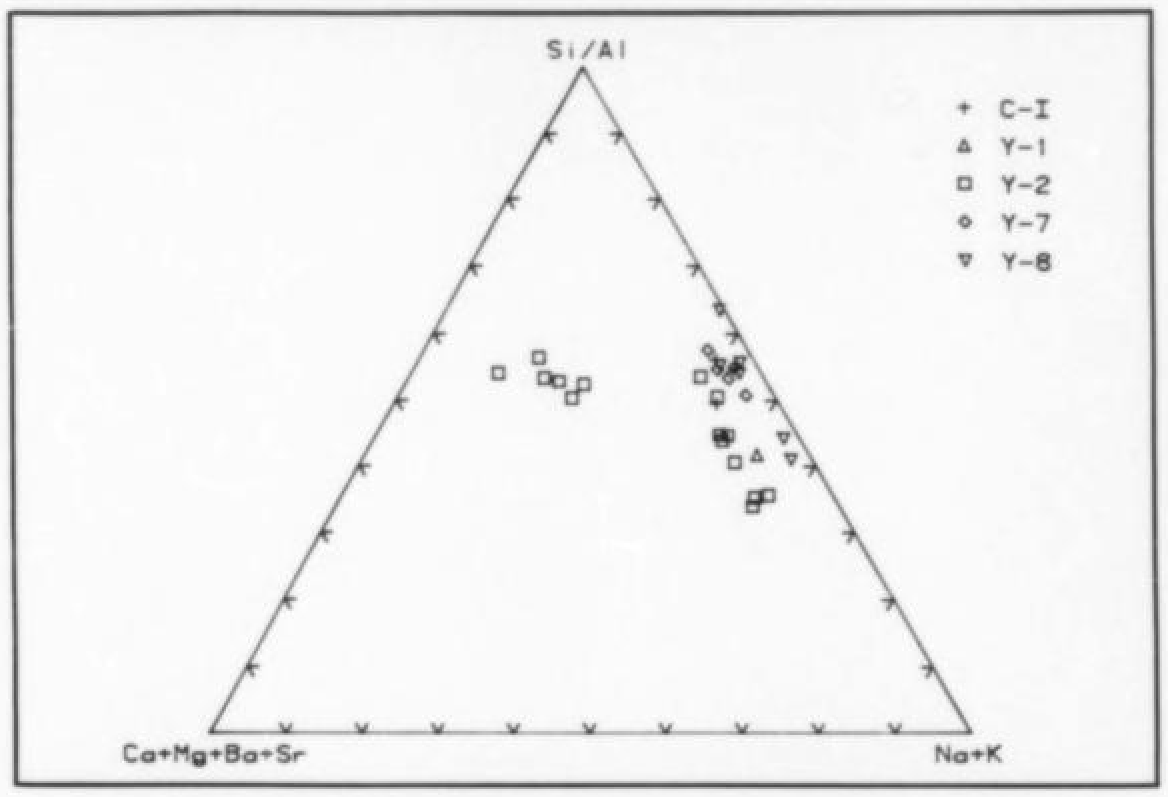

Figure 10. **Scanning electron micrograph of tabular heulandite crystals with later boxwork of montmorillonite, in core cuttings recovered from ~17 m in drill hole Y-6. Scale bar is 5 microns.**

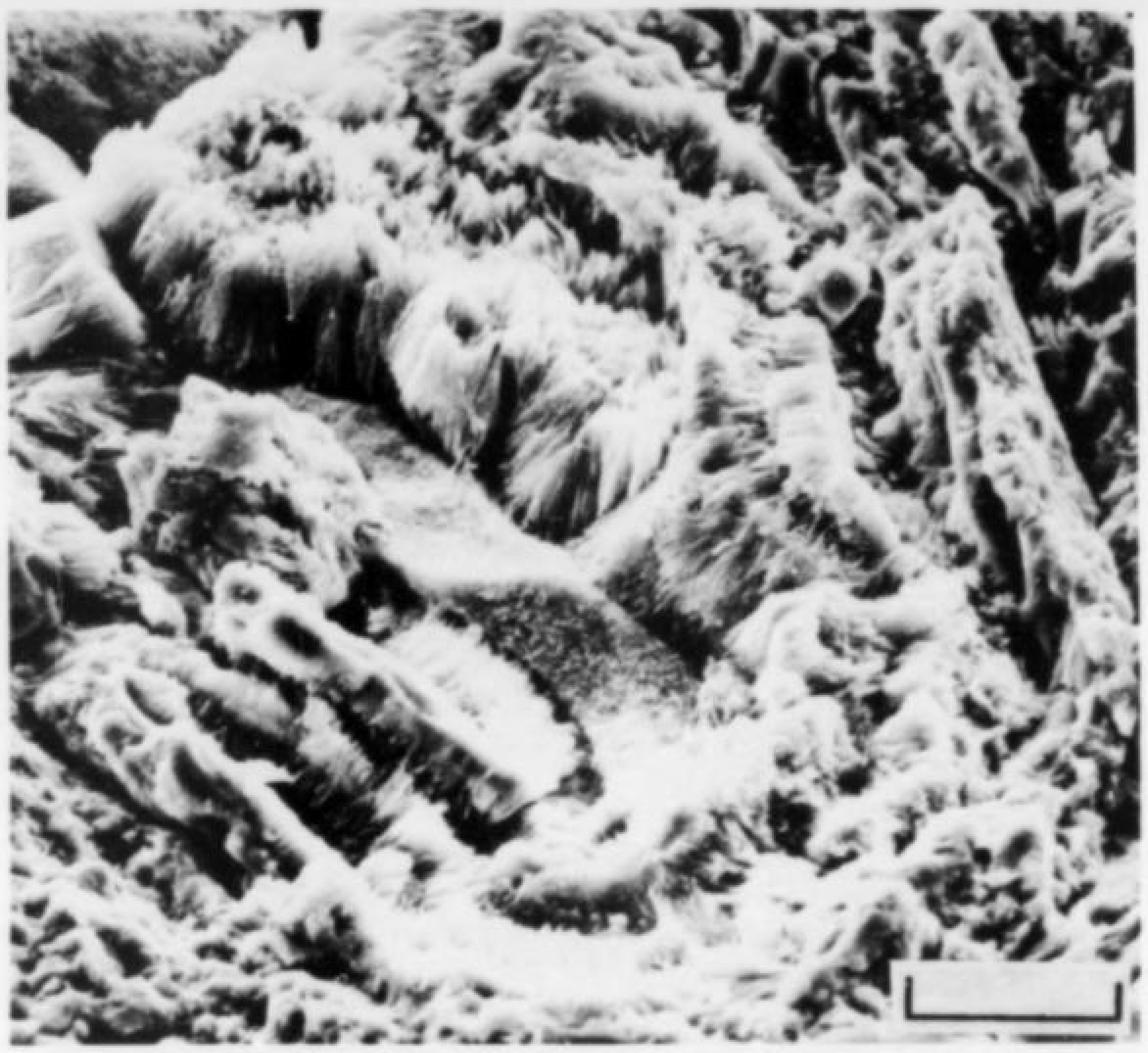

Figure 11. **Mole plot of heulandite-group zeolites in drill-core samples from Yellowstone National Park (modified from Alietti, 1972). Data for drill hole C-I are from Fenner (1936) and D. E. White (unpublished data, 1967); Y-1, from Honda and Muffler (1970); and for Y-2, Y-7, and Y-8, from microprobe analyses by M. H. Beeson (unpublished data, 1978).**

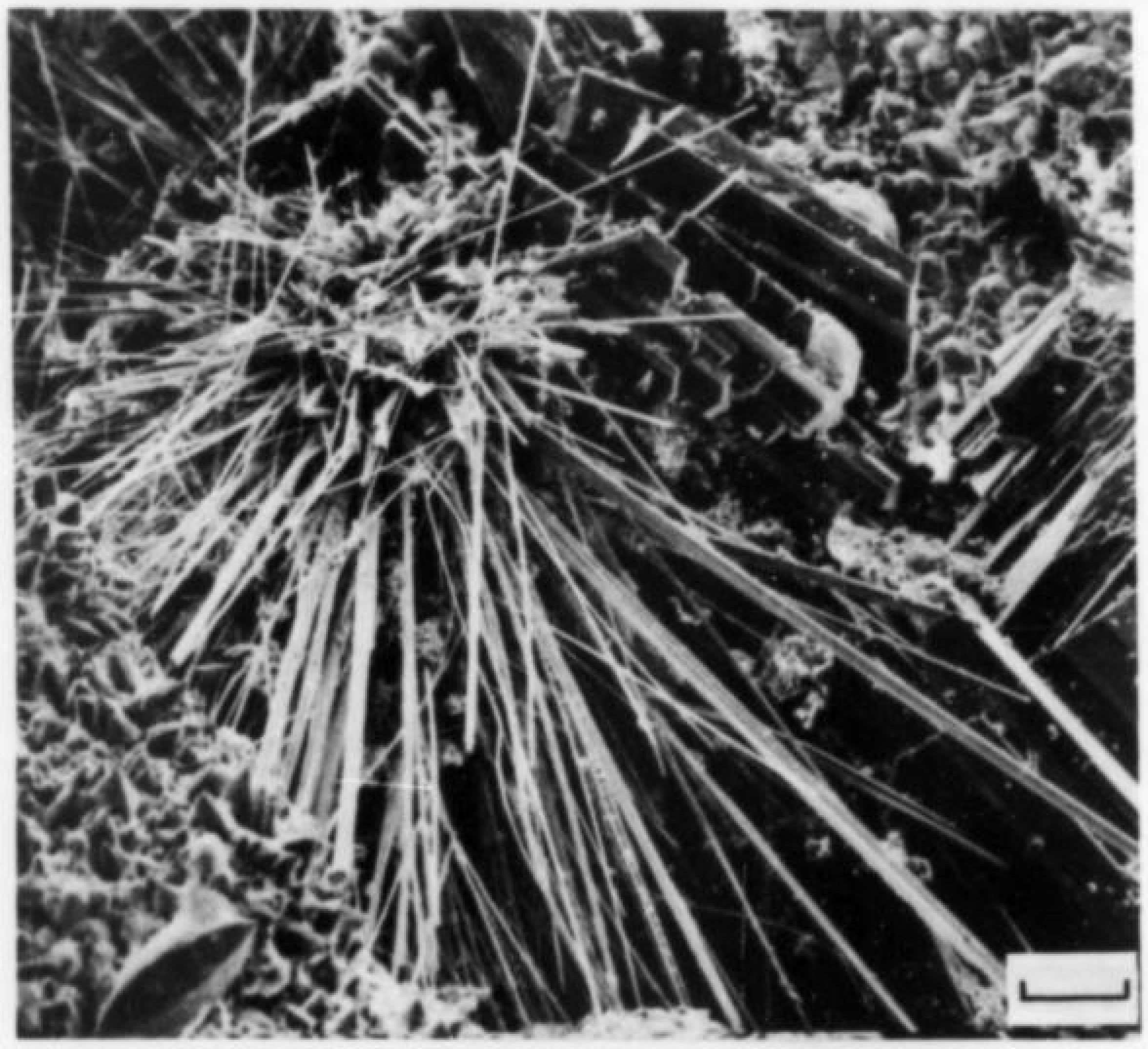

Figure 12. **Scanning electron micrograph of cavity from ~60 m in drill hole Y-3. Figure shows (in apparent order of paragenesis) tiny quartz crystals (lower left, upper right), dachiardite (diagonally from lower right to upper center), mordenite fibers, and tiny clusters of montmorillonite. Scale bar is 100 microns.**

(Ca + Mg + Ba + Sr), and sum of monovalent cations (Na + K) (Fig. 11), offers virtually the same three-fold division of heulandite-group minerals as do similar discrimination diagrams of Alietti (1972). The microprobe data along with analyses from C-I (Fenner, 1936; D. E. White, U.S. Geological Survey, unpublished data, 1967) and Y-1 (Honda and Muffler, 1970) fall into two distinct groups according to divalent cation content. The divalent cation content of the samples consists almost exclusively of calcium, although samples from drill hole C-I also contain minor magnesium and barium. None of the samples contain any detectable strontium. Molecular percentages of calcium in clinoptilolite from drill holes C-I, Y-1, Y-7, and Y-8 ranges from 0.06 to 0.67 percent. In the samples from drill hole Y-2, calcium varies from 0.75 to 1.37 percent for clinoptilolite and from 2.11 to 2.51 percent for intermediate heulandite.

Mordenite ($(Ca,Na_2,K_2)(Al_2Si_{10})O_{24}\cdot 7H_2O$)

Mordenite was found in 10 of the cores studied and appears to be independent of temperature except that it rarely occurs at lower temperatures in about the upper 15 m of drill core. Mordenite in the Yellowstone drill cores occurs as replacement of glass and as cavity, fracture, and vein fillings. The arrangement of feathery mordenite fibers in Figure 4 highlights the remnant perlitic texture of the altered glassy rhyolite. Where mordenite occurs as a cavity filling, it typically displays radiating clusters of fibers (Fig. 12), spongy mats of interwoven, long, thin, fibrous crystals (Fig. 13),

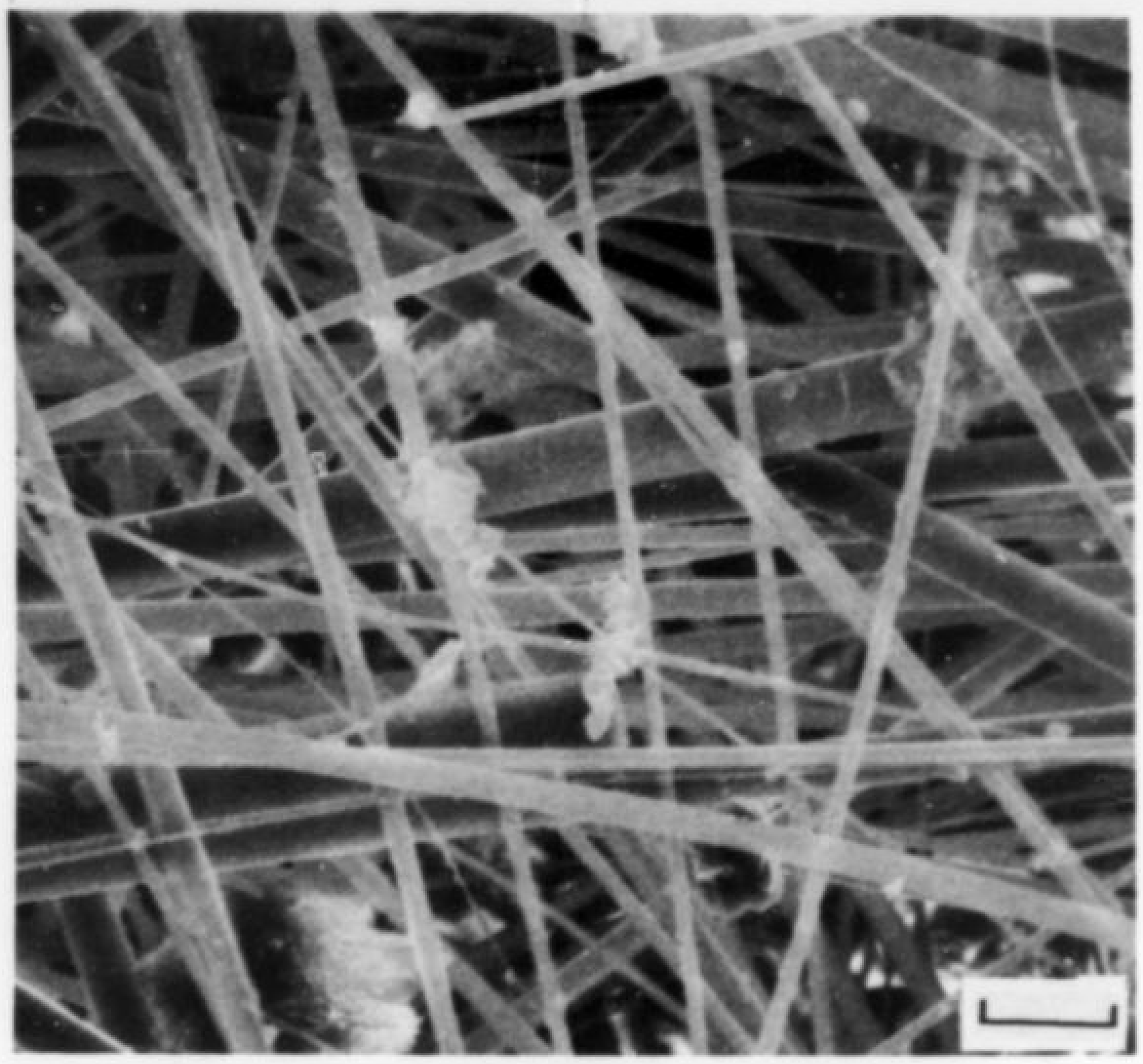

Figure 13. **Scanning electron micrograph of a spongy mat of interwoven, long, thin, fibrous mordenite from ~52 m in drill hole Y-2. Several crystals are partly coated by later clusters of tiny quartz crystals (center) and a boxwork montmorillonite (left lower center). Scale bar is 10 microns.**

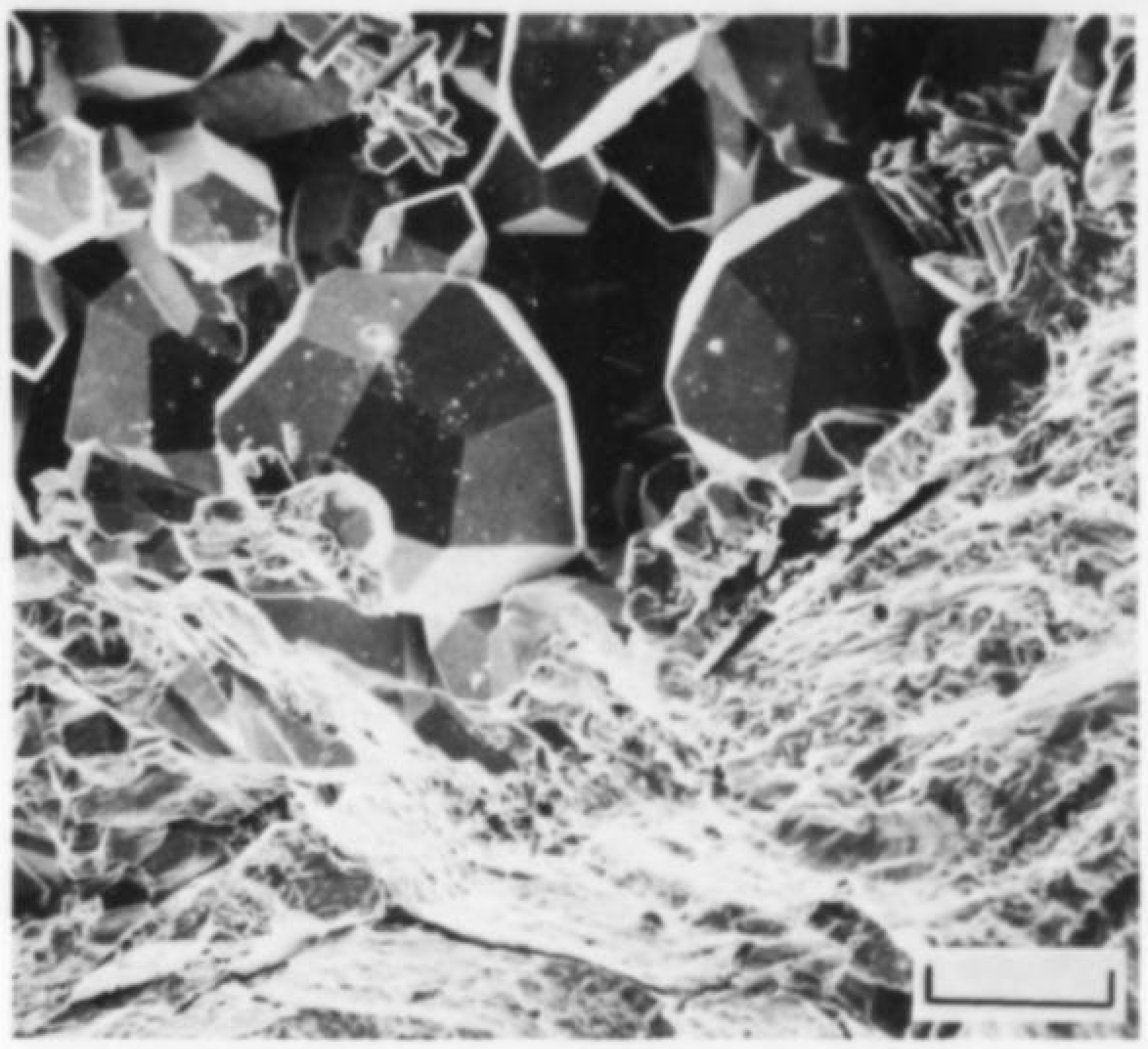

Figure 14. **Scanning electron micrograph of analcime crystals from ~28 m in drill hole Y-3. A few scattered clusters of montmorillonite platelets were deposited later. Scale bar is 10 microns.**

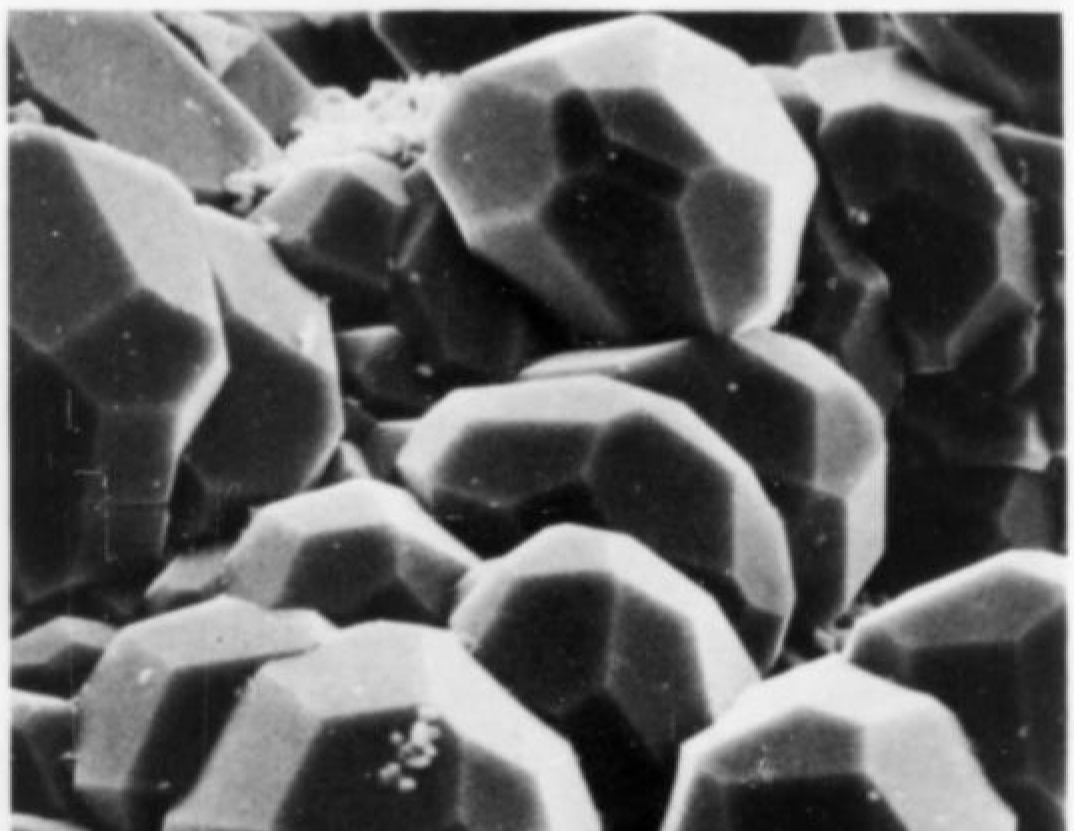

Figure 15. **Scanning electron micrograph showing pseudocubic wairakite crystals deposited with euhedral quartz crystals in a cavity from ~150 m in drill hole Y-2. Scale bar is 100 microns.**

and delicate discrete needles. Mordenite commonly seems to be a late-forming hydrothermal mineral; in one sample, shown in Figure 12, mordenite is later than quartz and dachiardite, and earlier than montmorillonite.

Analcime-wairakite

Analcime ($NaAlSi_2O_6 \cdot 2H_2O$) occurs as open-space fillings in six of the Yellowstone drill cores. The distribution of analcime is probably controlled by chemical factors rather than by temperature because the mineral is found at nearly any depth. In fact, euhedral trapezohedra of analcime (Fig. 14) are typically restricted to narrow zones, and are associated with quartz. These analcime-quartz zones commonly alternate with α-cristobalite-mordenite-clinoptilolite zones (Honda and Muffler, 1970; Keith *et al.*, 1978b).

Wairakite ($Ca(Al_2Si_4)O_{12} \cdot 2H_2O$), a rare mineral in the Yellowstone drill cores, was found only in narrow, restricted zones in drill holes Y-2 and Y-13. Wairakite is difficult to distinguish from analcime in SEM micrographs because it displays pseudocubic forms (Fig. 15). The two minerals can be distinguished by X-ray diffraction and by EDAX because analcime contains much more sodium than calcium, and wairakite contains the reverse. In drill hole Y-13, however, crystals containing both calcium and sodium were found (Keith and Beeson, in preparation) (Figs. 16a, and 16b). Electron microprobe analyses of an analcime (sodium-rich) zone (Fig. 16a) near the center of the crystal gave a composition of $An_{.87}Wa_{.13}$ and an analysis of the wairakite (calcium-rich) zone (Fig. 16b) gave $An_{.13}Wa_{.87}$. These results contrast with those for analcime from about 67 m in drill hole Y-1 ($An_{.99\text{-}1.00}Wa_{.01\text{-}0}$) that is not associated with a calcium-rich phase. The potassium-rich zone in Figure 16a may represent an adularia nucleus around which the zeolite crystal formed.

Laumontite ($Ca(Al_2Si_4)O_{12} \cdot 4H_2O$)

Laumontite, another calcium-rich zeolite, has been found as cavity or fracture fillings in only three of the Yellowstone drill cores. The monoclinic crystals typically occur in radiating clusters (Fig. 17) and are generally quite large (as much as 1 mm) in comparison to crystals of other associated hydrothermal minerals. In drill hole Y-3, laumontite occurs throughout the lower half of the core, where the temperature was about 140° to 196°C; whereas in drill core Y-13, laumontite occurs in only a few pieces of core at a temperature of about 160°C. In drill hole Y-2, laumontite is restricted to the bottom 8 m of drill core at a temperature of about 200°C.

Dachiardite ($(Ca,Na,K_2)_5(Al_{10}Si_{38})O_{96} \cdot 25H_2O$)

Dachiardite, a relatively rare zeolite, has been reported from only a few localities in Italy, Japan, and the United States (Sheridan and

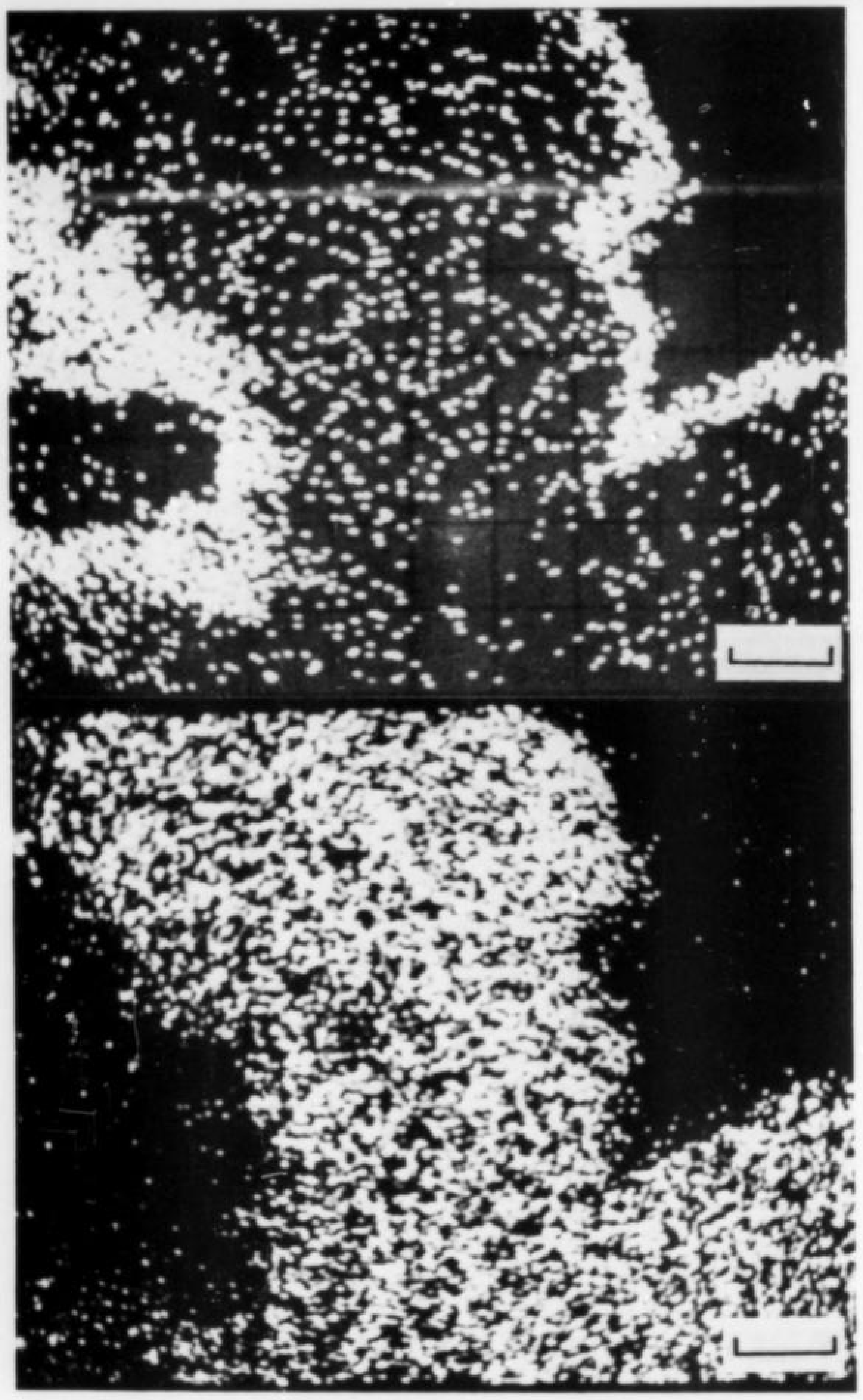

Figure 16. **Electron microprobe beam scans across part of a zeolite crystal from ~50 m in drill hole Y-13. In both photographs, the center of the crystal is at left, and part of the outer rim is near the upper right-hand corner of the scan. Scale bar is 14 microns. (a) Distribution of sodium. Crystal is sodium-rich analcime near the center and at the rim (brightest areas). Innermost part contains abundant potassium (coincident with the dark oblong part). (b) Distribution of calcium in the same area. Between the center and the rim is a patch of calcium-rich wairakite (brightest area).**

Maisano, 1976; Wise and Tschernich, 1978) where it occurs in pegmatites, altered volcanic rocks, and hydrothermally altered rocks. Dachiardite is found as isolated occurrences or in narrow, restricted zones in four of the Yellowstone drill cores. The mineral does not appear to be confined by temperature because it was identified near both the top and the bottom of drill hole Y-2 (Fig. 18) but nowhere in between. In drill hole Y-6, dachiardite occurs as stubby crystals intergrown with fibrous mordenite (Fig. 19) and in drill hole Y-3, as radiating clusters of relatively large crystals (Fig. 20).

Figure 17. **Scanning electron micrograph of laumontite crystals from ~86 m in drill hole Y-3. Fine particles on crystals are mixed-layer illite-montmorillonite. Scale bar is 300 microns.**

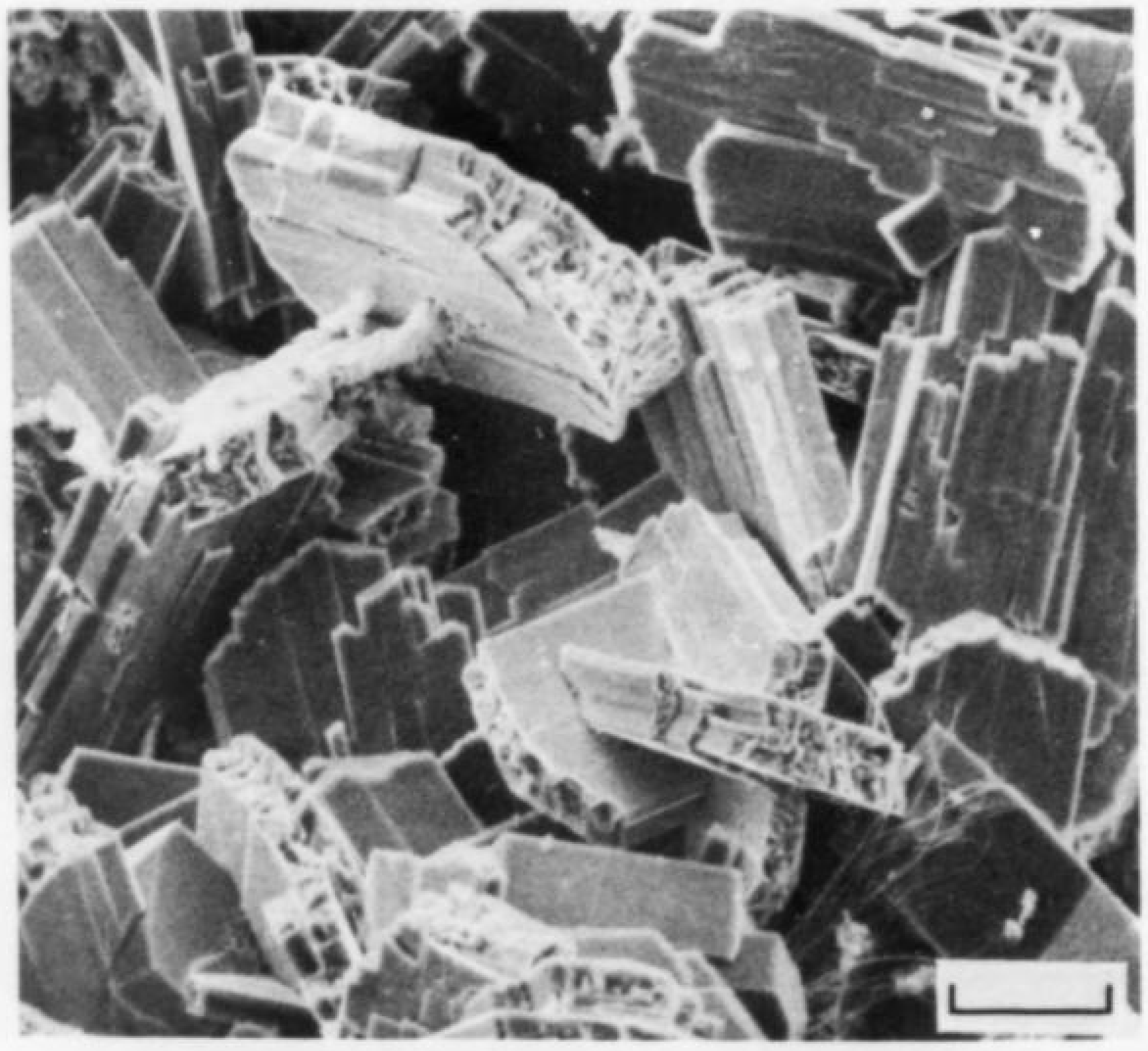

Figure 18. **Scanning electron micrograph of dachiardite crystals intergrown with clinoptilolite (lower right) from 23 m in drill hole Y-2. Fine mordenite fibers and scattered coatings of montmorillonite are later than the dachiardite. Scale bar is 50 microns.**

Erionite $(Ca,Na_2K_2)_4(Al_8Si_{28})O_{72}\cdot 27H_2O$

Erionite, a fairly common zeolite mineral in sedimentary tuff deposits (Mumpton and Ormsby, 1976), is limited to open-space fillings in a few isolated samples from four of the Yellowstone cores. Honda and Muffler (1970) reported erionite in drill hole Y-1, and Honda and Sasaki (1977) presented SEM photographs showing bundles and rods of erionite from drill hole Y-1. Radiating bundles of hexagonal, fibrous erionite crystals (identified by X-ray diffraction) were found in cavities of a single sample from drill hole Y-2 (Fig. 21). Erionite has also been identified in core from near the tops of drill holes Y-5 and Y-8 (Keith and Muffler, 1978; Keith *et al.*, 1978b). In all of the above cores, erionite is restricted to temperatures below 110°C.

Yugawaralite-stilbite (?)

Yugawaralite ($Ca(Al_2Si_6)O_{16}\cdot 4H_2O$), another rare zeolite, occurs in only two of the Yellowstone cores. In drill hole Y-2, yugawaralite

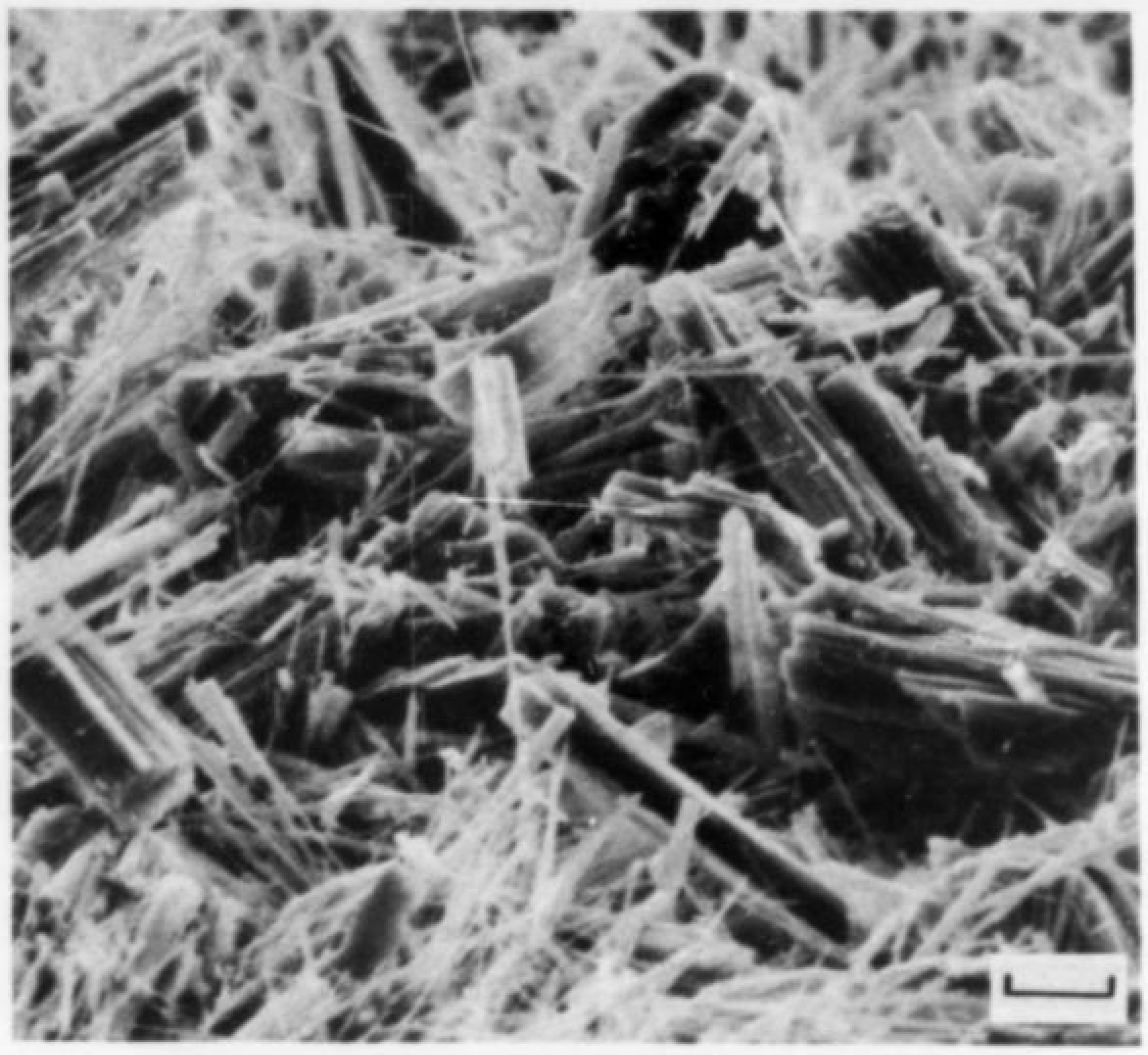

Figure 19. **Scanning electron micrograph showing intergrown fibrous mordenite and stubby dachiardite crystals from ~72 m in drill hole Y-6. Scale bar is 10 microns.**

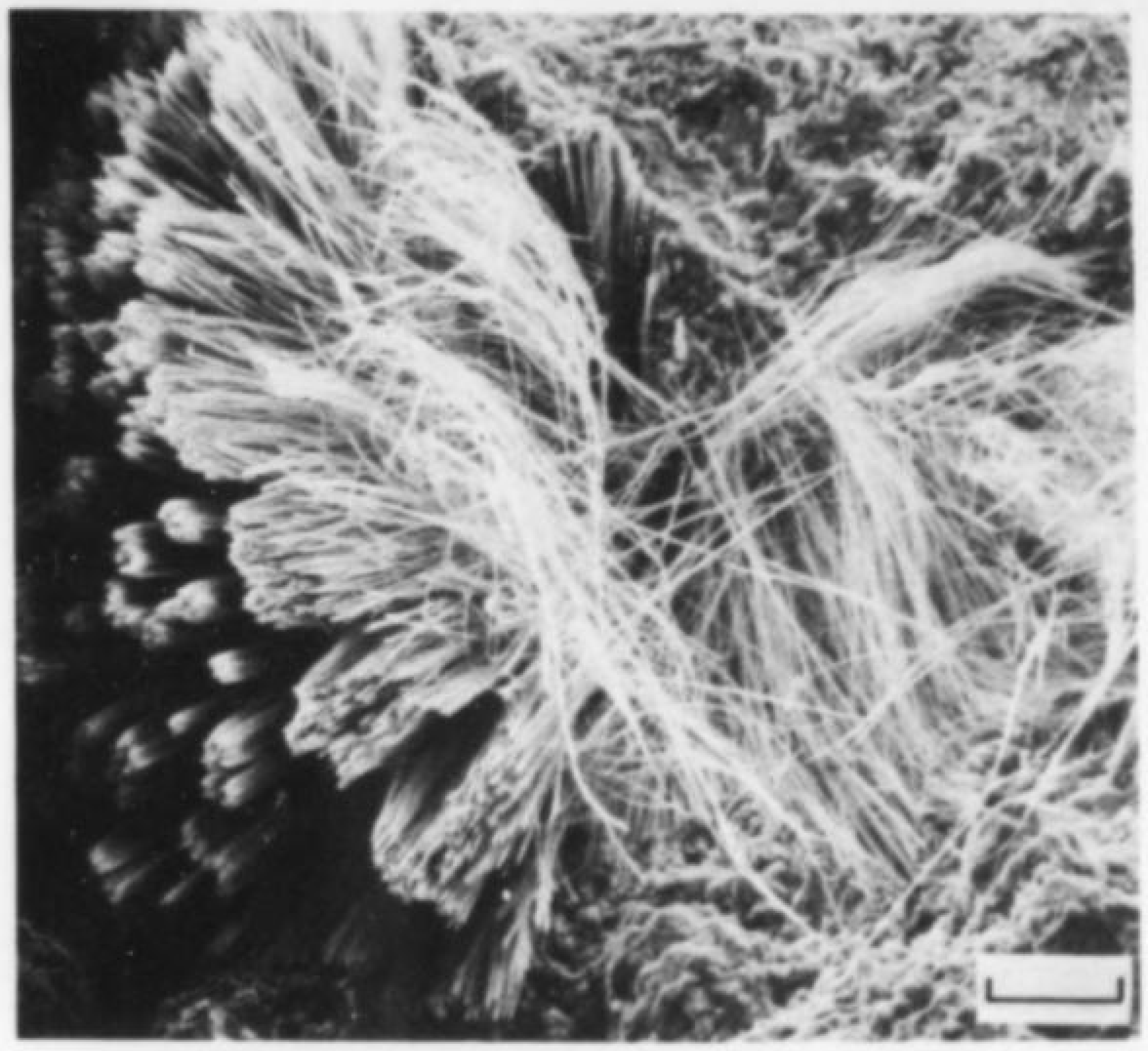

Figure 21. **Scanning electron micrograph of radiating bundles of fibrous erionite crystals from ~11 m in drill hole Y-2. Scale bar is 50 microns.**

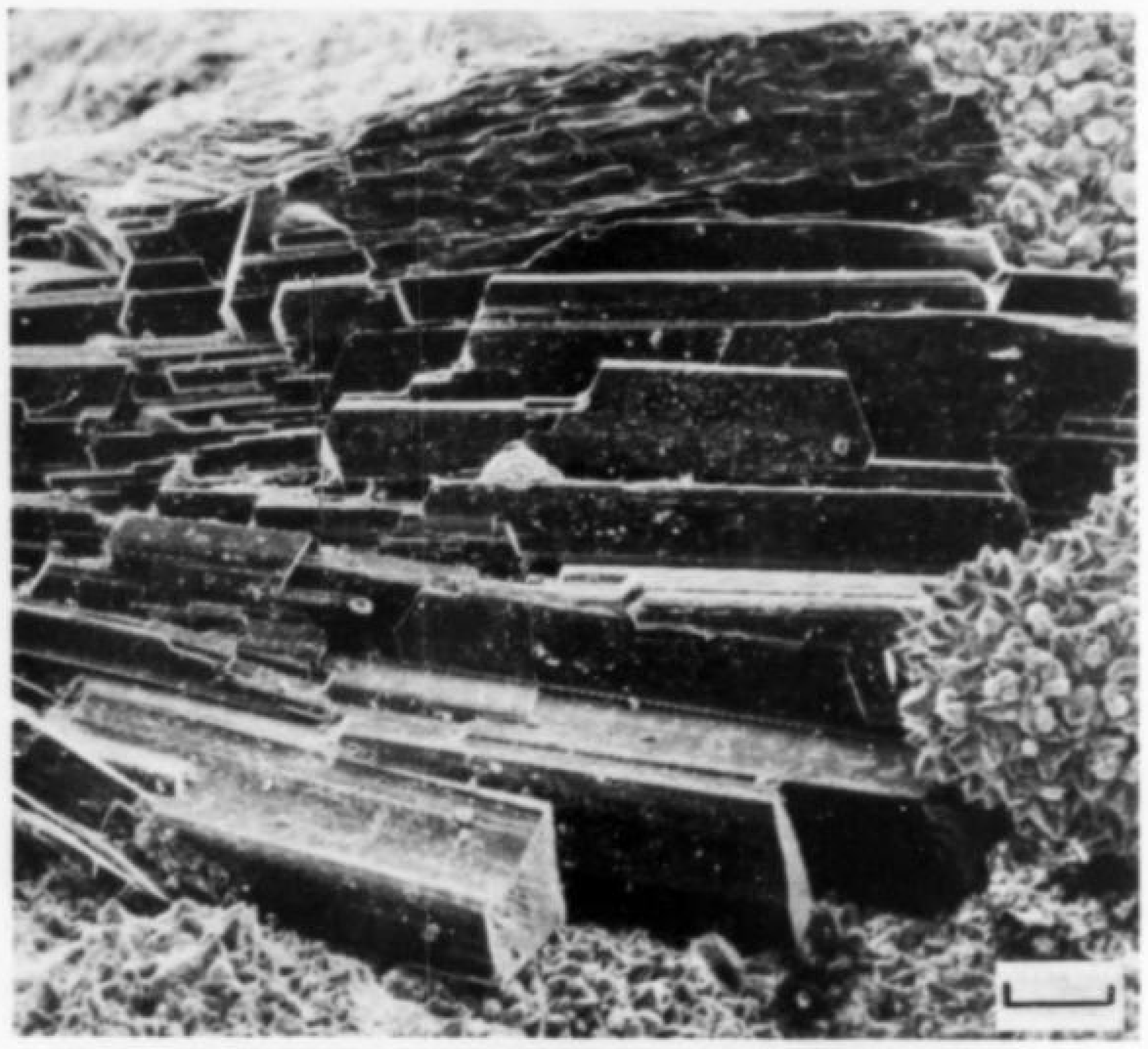

Figure 20. **Scanning electron micrograph of a large radiating cluster of dachiardite crystals deposited on hydrothermal quartz crystals in a cavity at ~60 m in drill hole Y-3. Scale bar is 200 microns.**

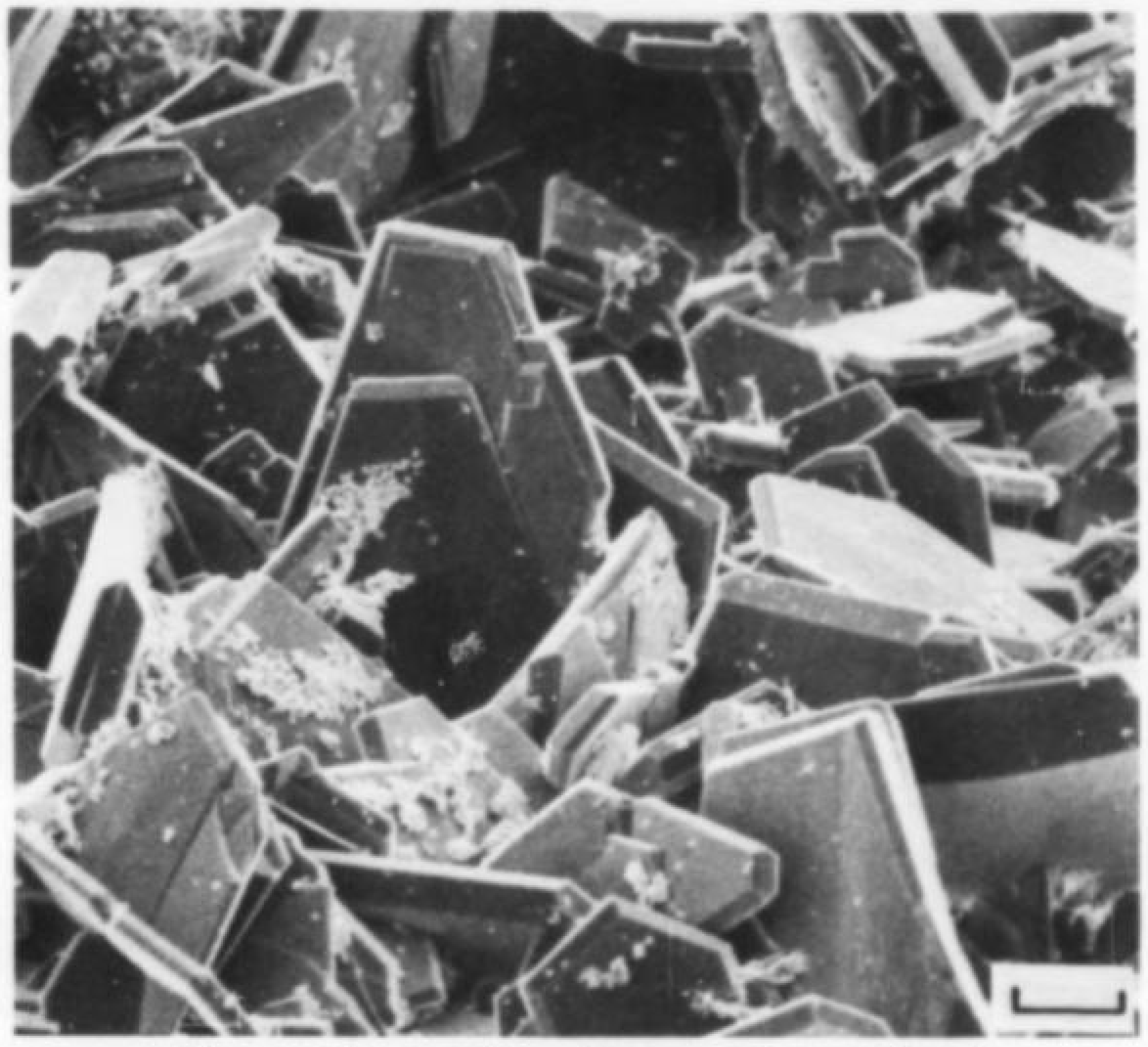

Figure 22. **Scanning electron micrograph of tabular yugawaralite crystals from a fracture surface at ~73 m in drill hole Y-3. Most crystals are coated by later montmorillonite. Scale bar is 50 microns.**

is restricted to a narrow zone at a temperature of about 200°C, whereas in drill hole Y-3, it is found in a zone where the temperature is about 170°C. In both cores, the clear, thin, tabular yugawaralite crystals occur as open-space deposits in fractures or cavities (Fig. 22). The mineral was previously reported in extrusive rocks of Japan, India, Iceland, Alaska, and Sardinia (Wise, 1978). Stilbite [$NaCa_2(Al_5Si_{13})O_{36}\cdot 14H_2O$] was tentatively identified by X-ray diffraction in association with yugawaralite on a fracture surface at about 67 m in drill hole Y-3 (Fig. 23).

CALCIUM SILICATE HYDRATES

Truscottite ($(Ca,Mn)_2Si_4O_9(OH)_2$)

Truscottite is a rare mineral previously reported in Sumatra and Japan (Minato and Kato, 1967), Taiwan (Juan *et al.*, 1970), and Hawaii (Grose and Keller, 1976). In the Yellowstone drill cores, truscottite fills veinlets in four of the cores, usually as clear, purple or green, intergrown, thin, tabular, hexagonal crystals (Fig. 24), as individual tabular hexagonal crystals (Fig. 25), or as rosettes of tabular crystals (Fig. 26). In three of the four cores, the zones containing truscottite had temperatures between 175° and 200°C; however, in the fourth drill hole (C-I), truscottite occurs at a depth of only 19 m, where the temperature was probably only 120°C (White *et al.*, 1975).

Okenite ($CaSi_2O_4(OH)_2\cdot H_2O$)

Heller and Taylor (1956) indicated that okenite was previously recognized only in Greenland, the Faeroe Islands, and India, generally in basalt vesicles containing zeolites. Intergrown, white,

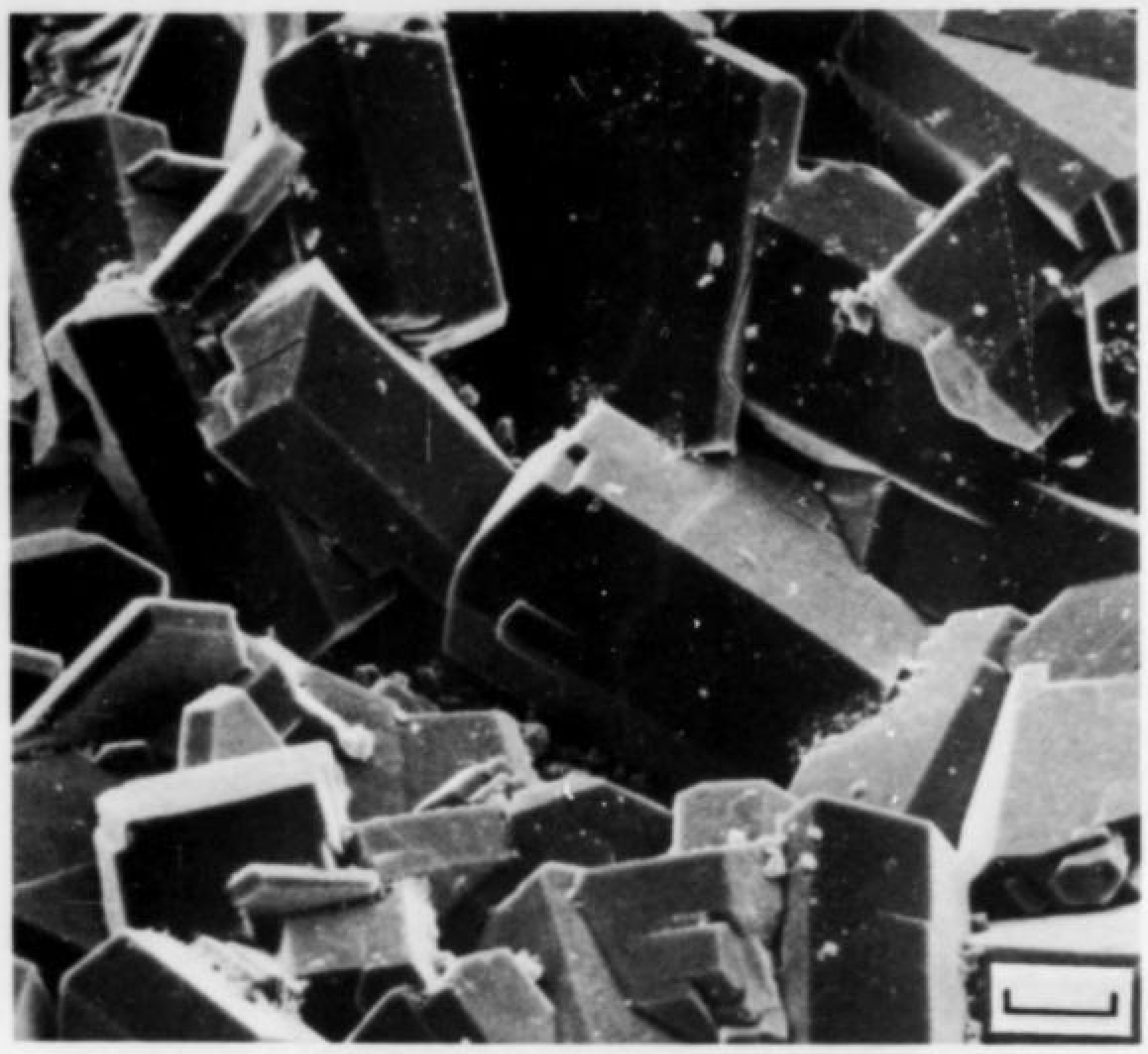

Figure 23. **Scanning electron micrograph of blocky stilbite (?) crystals intergrown with tabular yugawaralite from a fracture surface at ~73 m in drill hole Y-3. Scale bar is 30 microns.**

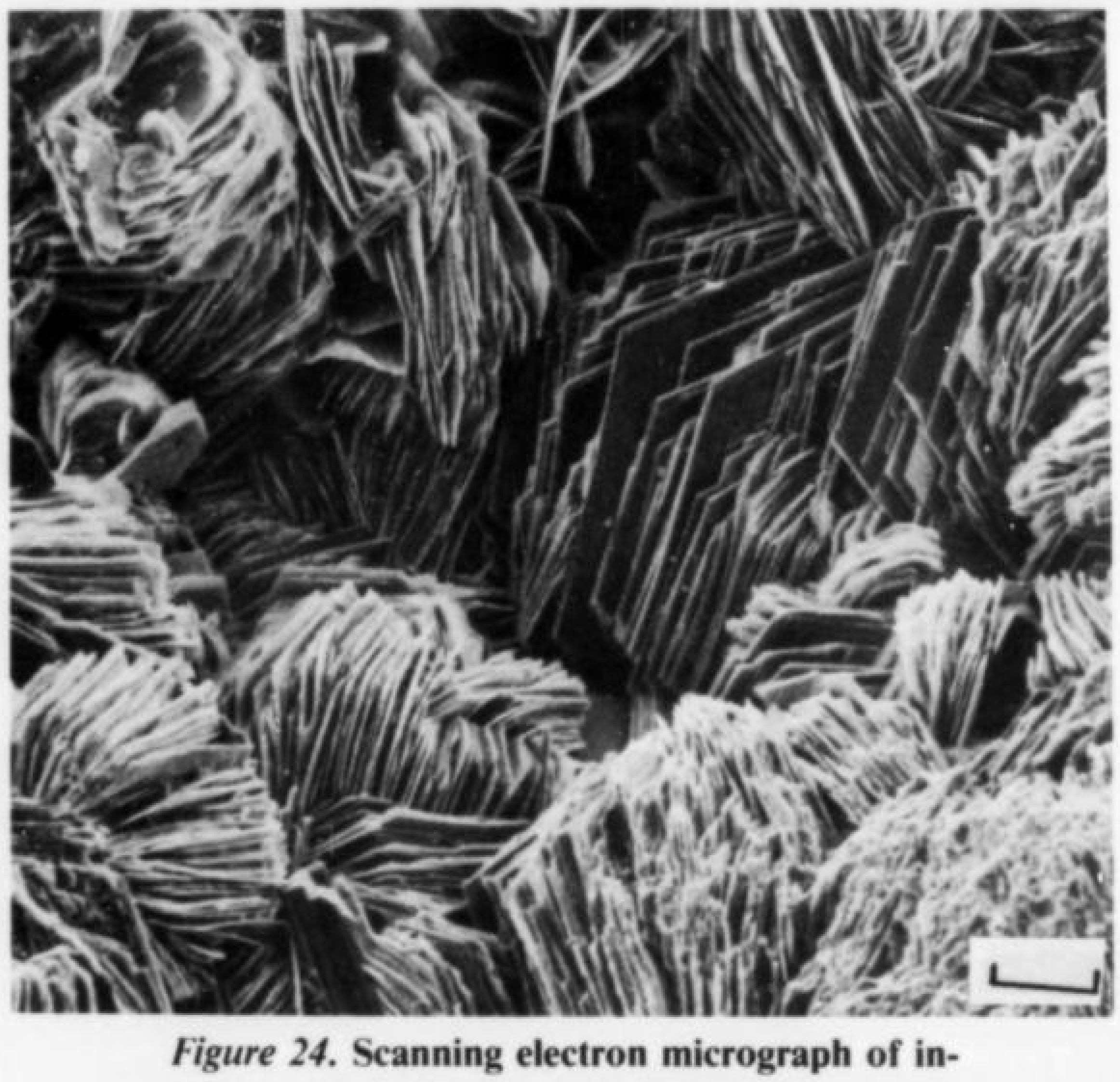

Figure 24. **Scanning electron micrograph of intergrown, tabular, hexagonal truscottite crystals from ~150 m in drill hole Y-2. Scale bar is 50 microns.**

platy okenite crystals occur in a single cavity at about 24 m in drill hole Y-13, where the temperature was probably about 130°C (Fig. 27).

Gyrolite ($Ca_2Si_3O_7(OH)_2 \cdot H_2O$)

Gyrolite was identified by X-ray diffraction in a single sample from drill hole C-I. The white mineral has a fibrous habit (Fig. 28), although Heller and Taylor (1956) indicated that it belongs to a lamellar group along with truscottite. The sample from a Yellowstone drill core was found at a temperature of about 125°C (White *et al.*, 1975), whereas gyrolite in drill cores from Iceland was reported to occur at somewhat higher temperatures (Kristmannsdottir and Tomasson, 1978).

Pectolite ($NaCa_2Si_3O_8(OH)$)

Pectolite was found filling cavities in two zones of drill hole Y-3 in association with hydrothermal aegirine (Bargar *et al.*, 1973). The mineral commonly occurs as white fibrous mats (Fig. 29) similar to mordenite; however, a few cavities contain radiating clusters of bladed pectolite crystals that formed later than quartz crystals (Fig. 30).

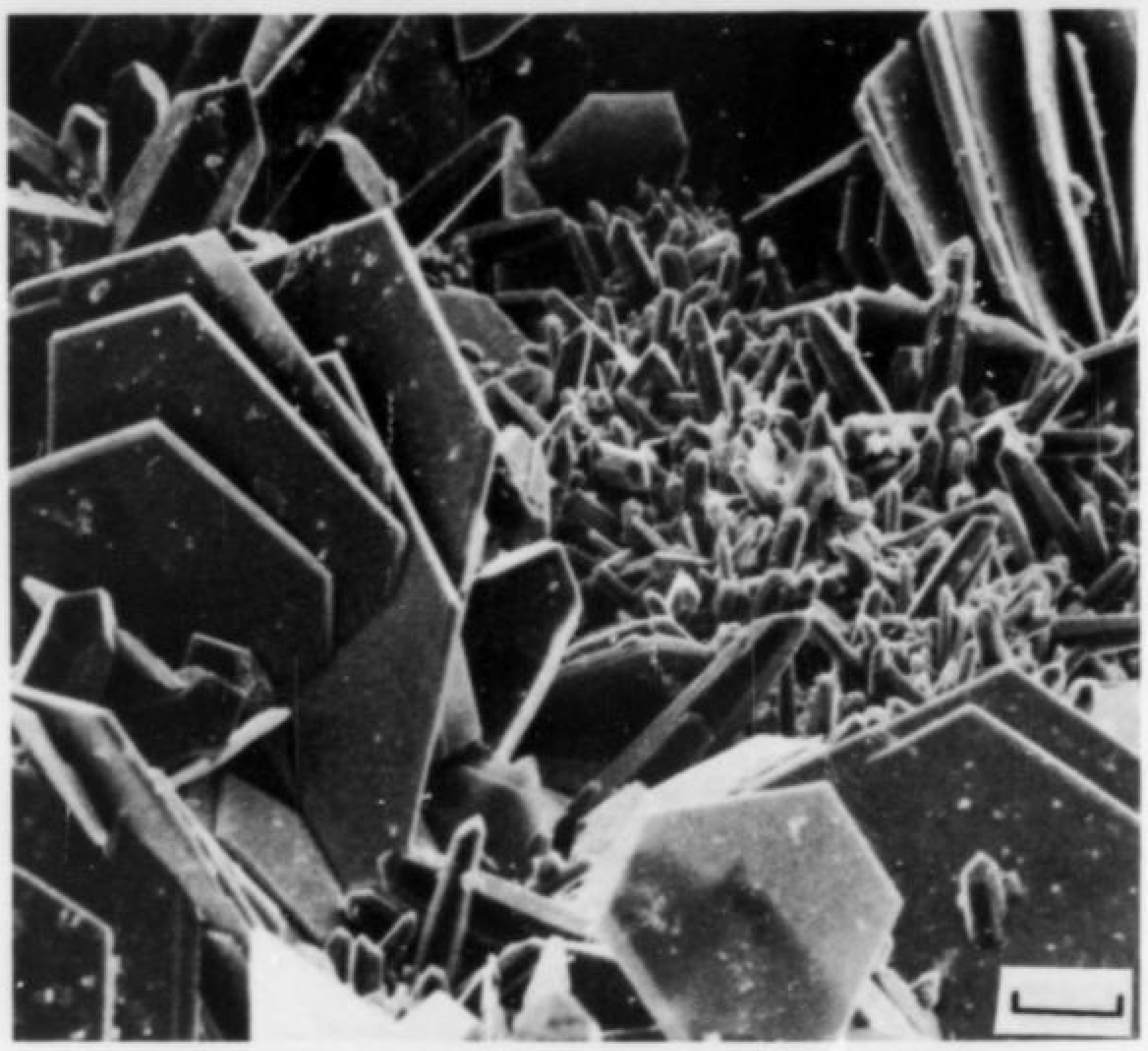

Figure 25. **Scanning electron micrograph showing the tabular hexagonal habit of truscottite deposited on quartz from ~90 m in drill hole Y-3. Scale bar is 30 microns.**

Figure 26. **Scanning electron micrograph of a rosette of tabular truscottite on leached potassium-feldspar from ~120 m in drill hole Y-13. Scale bar is 20 microns.**

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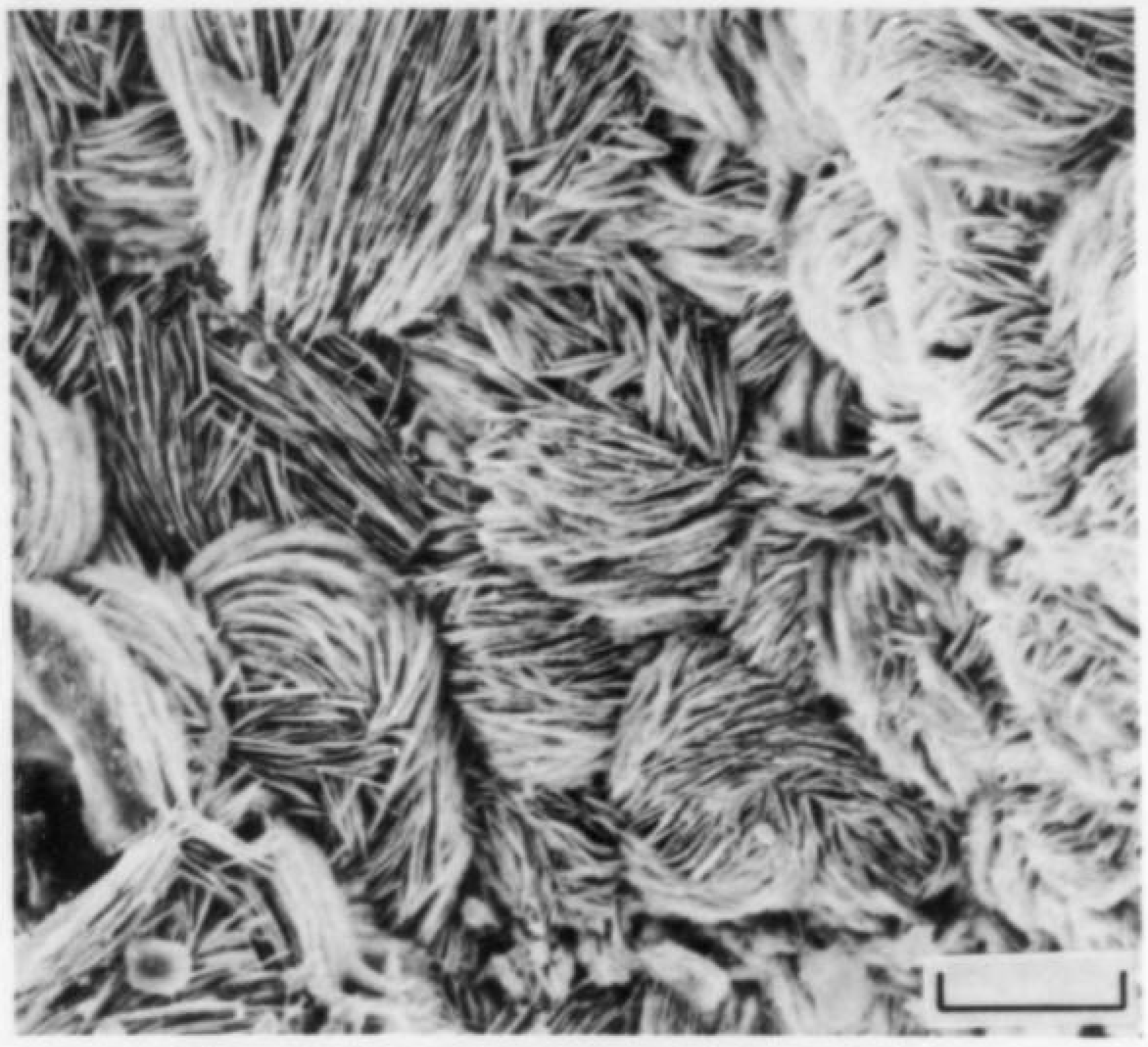

Figure 27. Scanning electron micrograph showing the intergrown, platy habit of okenite from ~24 m in drill hole Y-13. Scale bar is 20 microns.

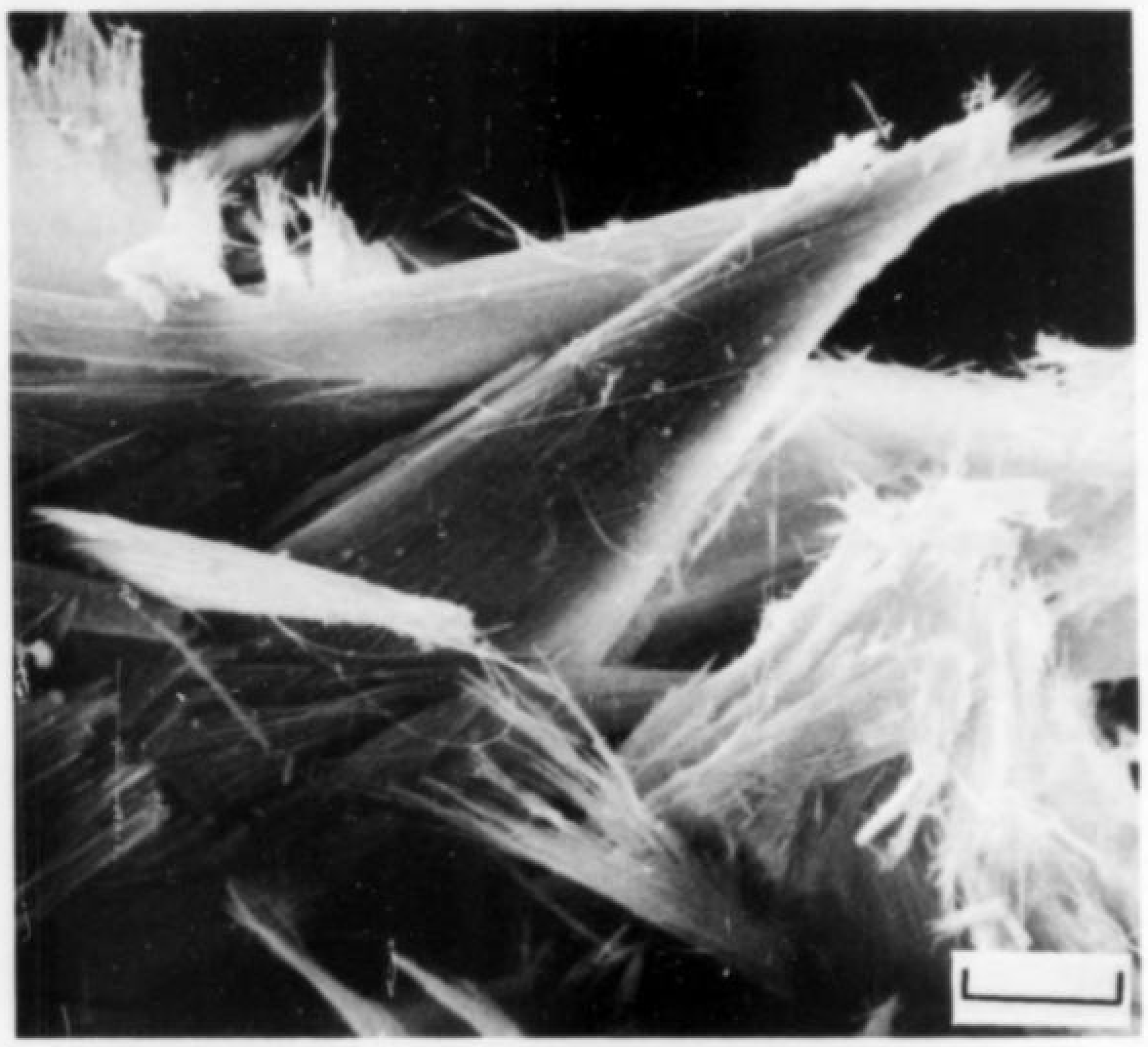

Figure 28. Scanning electron micrograph of fibrous gyrolite from ~28 m in drill hole C-I. Scale bar is 10 microns.

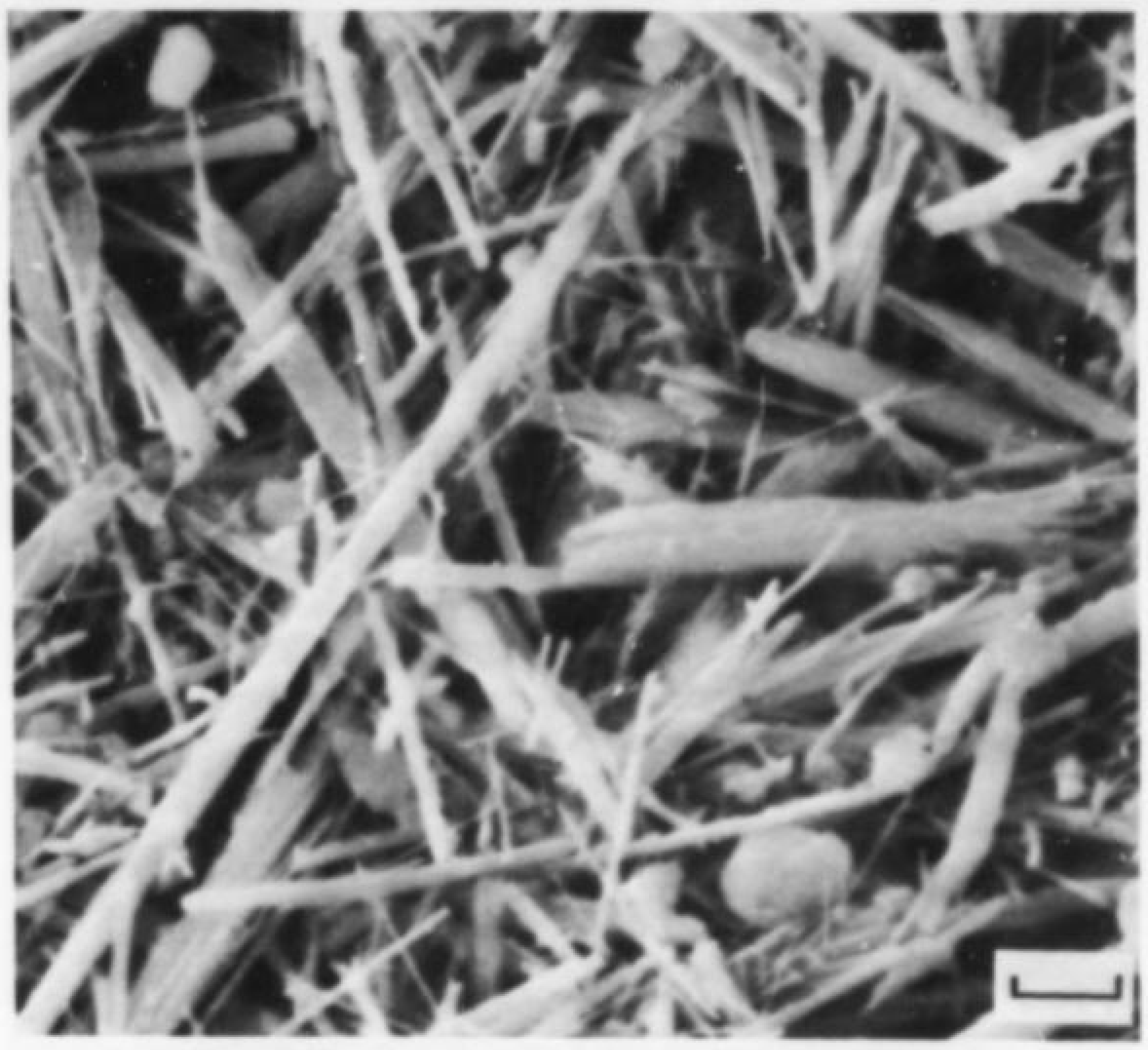

Figure 29. Scanning electron micrograph of an intergrown fibrous mat of pectolite from ~27 m in drill hole Y-3. Scale bar is 3 microns.

Figure 30. Scanning electron micrograph showing a radiating cluster of bladed pectolite crystals on hydrothermal quartz prisms from ~28 m in drill hole Y-3. Scale bar is 1 micron.

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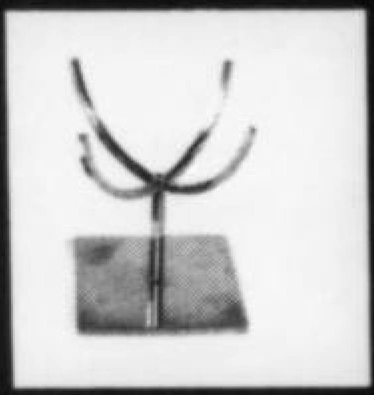

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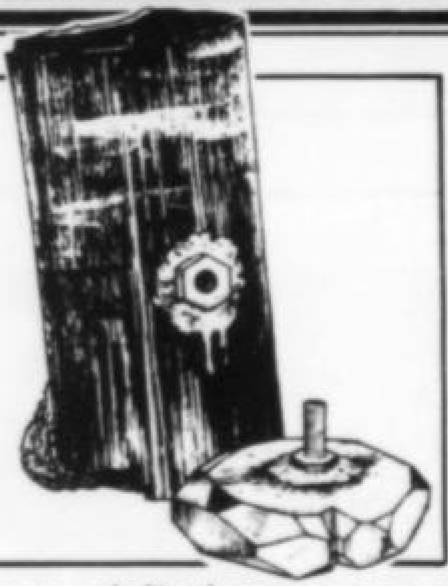

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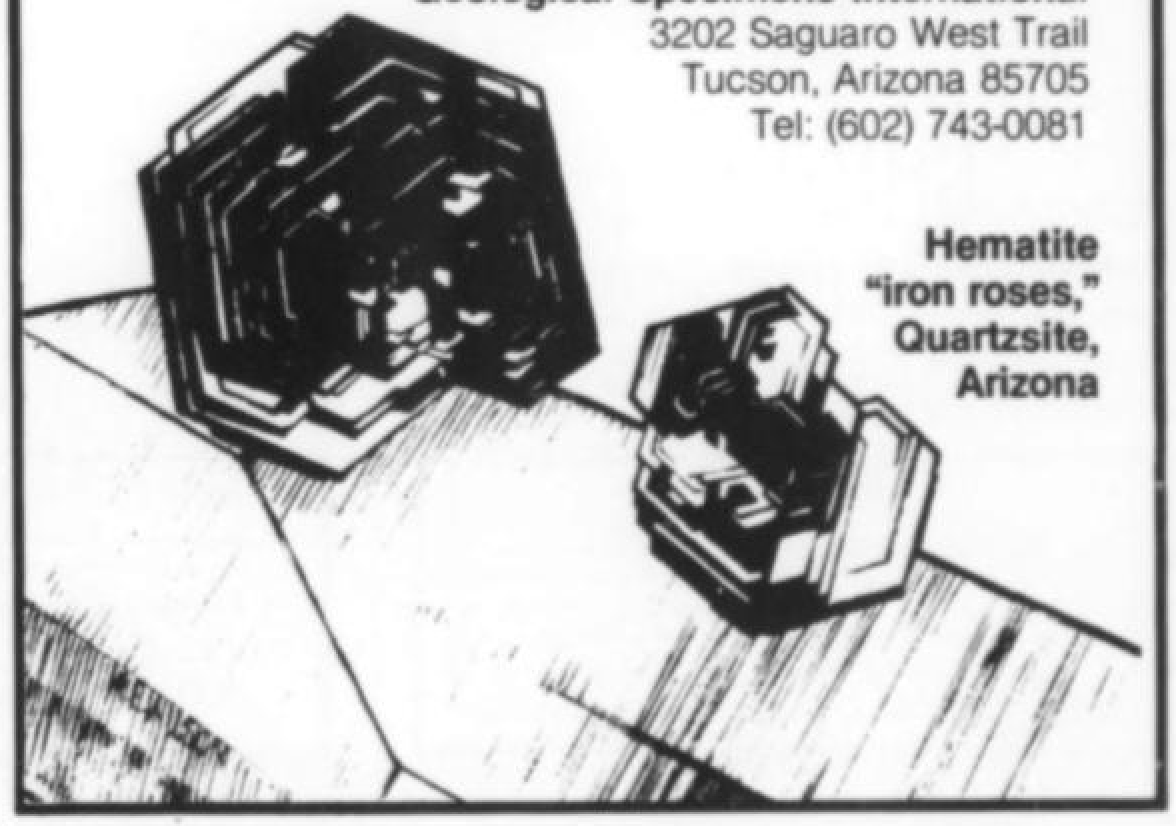

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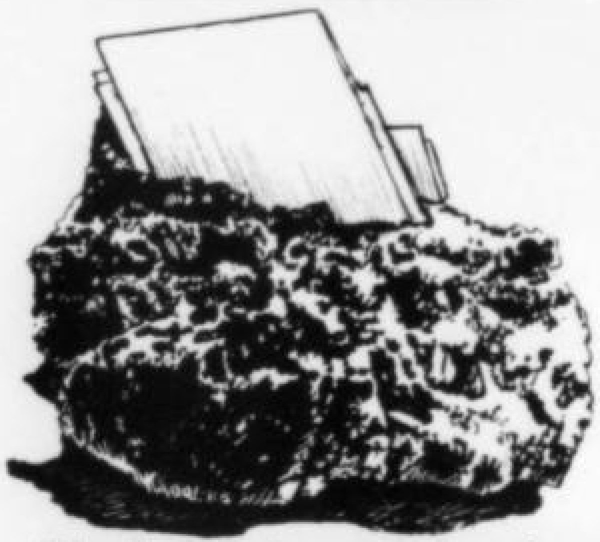

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Microminerals

by Violet Anderson

After so long not writing, I am likely to surface with a column of notes from the underworld. Or descend with the snows of yesteryear. Or decline into a remembrance of things past. Loose ends all over the place.

First, Vesuvius. From the underworld? Gianni Porcellini (address: Via Giarabub, 6 . . . 47037 Rimini . . . Italy) has sent me a dozen or so small specimens labeled Vesuvius which are almost incredibly crowded with crystals of many different minerals. In fact, to try and mount some of these specimens is to court frustration: what area to sacrifice to a pedestal?

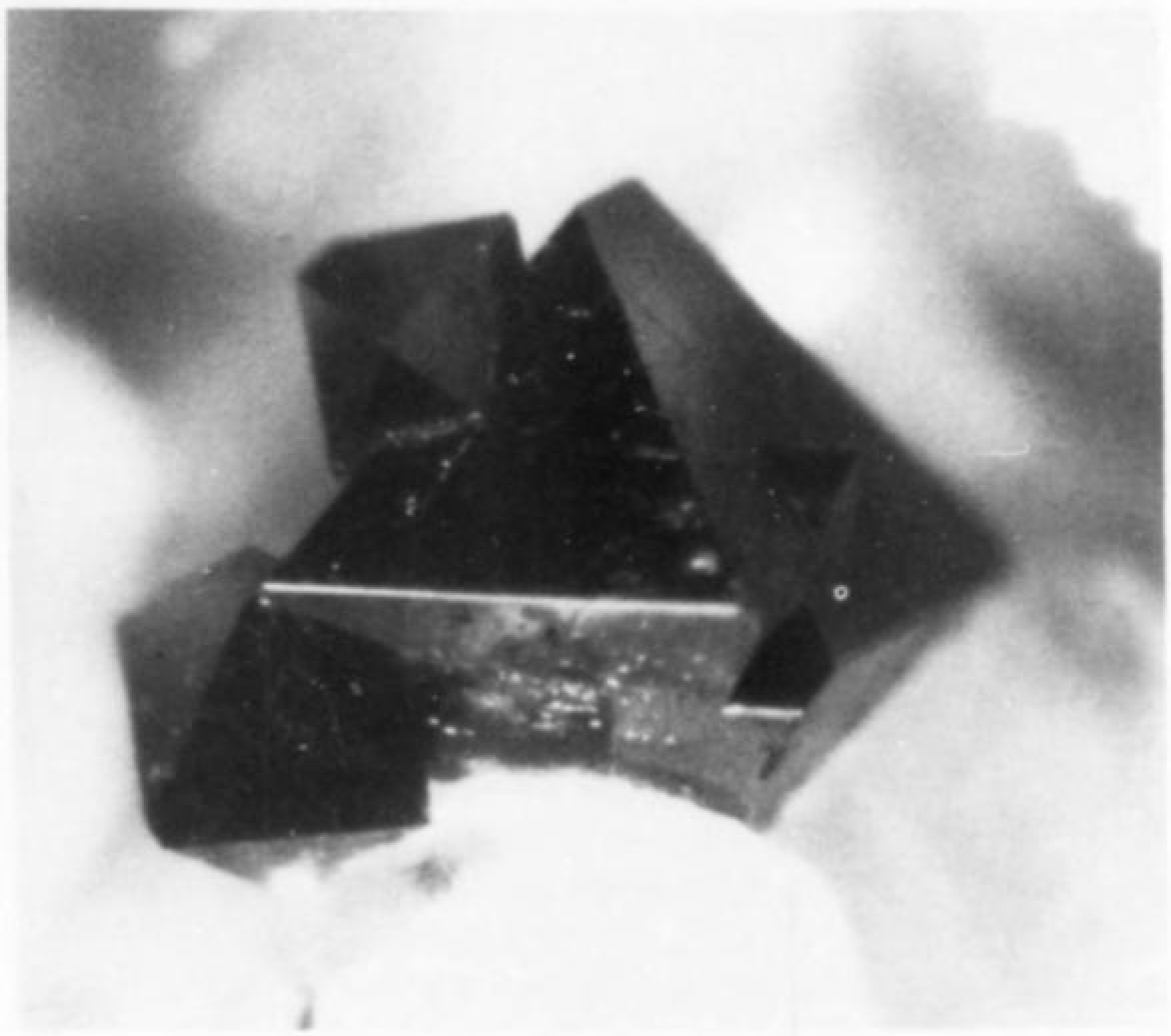

Figure 1. **Black spinel crystals from Vesuvius near Naples, Italy. The longest edge of the large crystal is about 0.6 mm in length. (Vi Anderson photo)**

Particularly attractive are the glossy black spinel octahedrons (Fig. 1), the greenish olivine crystals (some of which appear octahedral but reveal their non-isometric nature by the presence of a small prism face), crystals of dark, rich red vesuvianite, clear transparent tetragonal meionite (mostly made up of pyramidal faces), and pinkish sodalite (the crystals have some inner crackling but the faces, catching the light, are clear). There are fine nepheline crystals, plenty of well-shaped hornblende crystals, hematite, and muscovite almost glassy green (Fig. 2).

I must stress again that the interesting feature of this material is the number of species and quality rather than their rarity. One can be studying a specimen (less than an inch across) specifically to find yellow titanite, and discover as well crystals of nepheline, biotite, melanite, hematite, and some unknown acicular crystals.

Gianni Porcellini puts out a list which includes minerals from other regions of Italy as well and, although he has marked no prices on the list I have, he tells me in a letter that his specimens cost in the region of one to two dollars. I have only the material from around Naples to go on and cannot speak for the others.

Now, for the snows of yesteryear, there are the zeolites. I can begin to understand how one can become addicted to zeolites. Not so long ago there was that group of specimens from County Antrim, Ireland, which came my way, and because of which I have become so involved with gmelinite I doubt if I'll come out the other side. A letter from Hugh Heron from Queensburgh, South Africa, expresses his own special interest in herschelite, which is closely related to gmelinite and to chabazite. In discussing the sandwich type of gmelinite, which could be a composite of chabazite and gmelinite, he directs me to *Mineralogical Magazine,* **32,** 202–217 (1960). Here George P. Walker discusses gmelinite-bearing basalts in County Antrim, which are confined almost entirely to a narrow belt along the eastern seaboard. Reading the article, I came across a diagram of most complicated twinning of gmelinite and chabazite. It seemed a strong coincidence that just a few days preceding this I should have come into possession of some red-orange gmelinite from Mont St. Hilaire which seems not too dissimilar from the diagram. Who knows what will come out of it all with study?

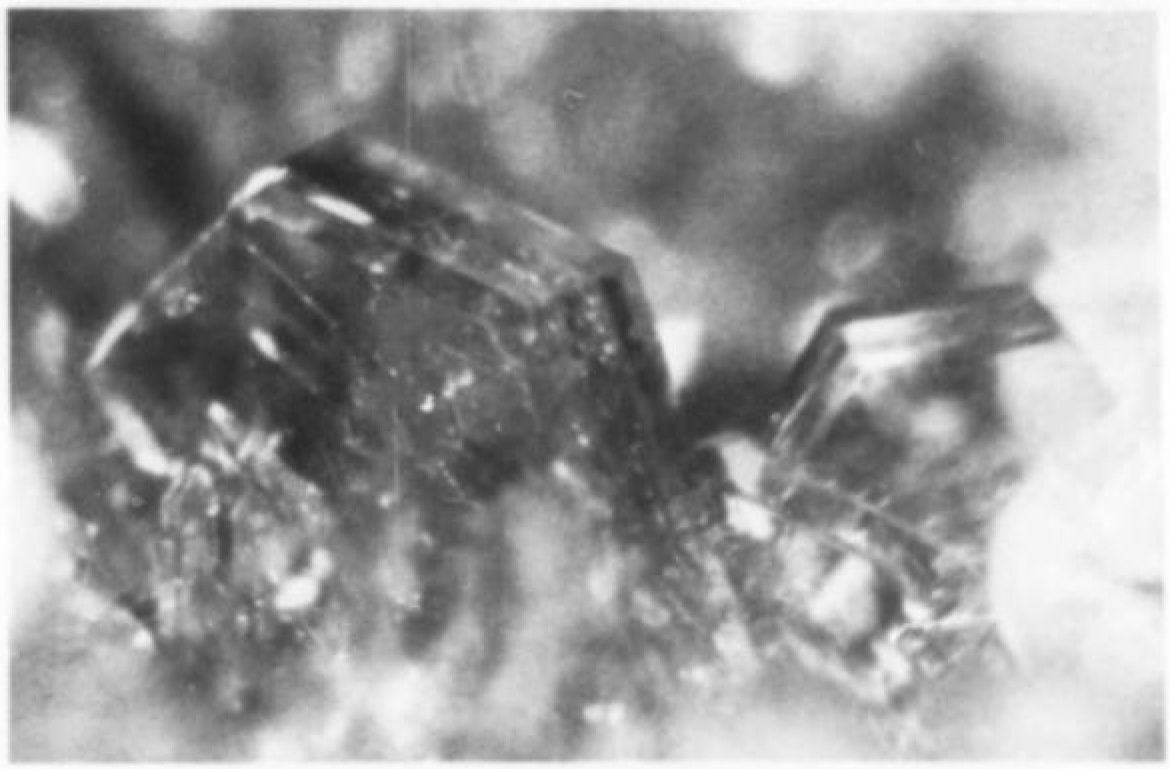

Figure 2. **Yellow-green muscovite crystals from Vesuvius near Naples, Italy. The largest crystal is about 0.9 mm across. (Vi Anderson photo)**

A chabazite-like white mineral (identified as such by George Chao of Carleton University, Ottawa), its crystals resembling the somewhat rounded six-sided plates of gmelinite, is also newly being found at Mont St. Hilaire.

On top of all this, there is Jules Bernhardt, and Robert Mudra. At the Baltimore Micromount Symposium in September 1979, Jules produced some well-crystallized edingtonite (another zeolite, as one would expect of Jules), from Ice River near Golden, B.C., Canada (my own country, no less), and some attractive mordenite sprays as needles across the orange background of a heulandite nodule (Rock Creek, Stevenson, Washington). He had also some erionite or offretite in colorless, quite distinct little needles (Rock Island Dam, Washington), different indeed from the erionite I have selected to show you in Figure 3.

Which brings me to Robert Mudra, who sent me about fifty specimens of zeolites, all from Arizona. You could do no better than trade with him for his silky erionite (Fig. 3). It is really white,

Figure 3. **Erionite crystals, white in color, from Thumb Butte, Graham County, Arizona. Field of view is about 4 mm. Vi Anderson photo.**

white, but difficult to demonstrate in a photograph without using grey tones; the white would burn out to a blur. The silky fibres seem to form cones, each cone nudging another, a flower-like habit very different from those Jules Bernhardt gave me, and from the fibrous erionite/offretite layers found elsewhere with levyne. The locality is the Thumb Butte area, Graham county, Arizona.

From the Horseshoe Dam area, Maricopa County, came most of the Arizona analcimes I received. The crystals are glass-clear, often covering some orange-red mineral which gives them a nice color. The area not covered by analcime crystals is brown.

From the same locality came hexagonal-shaped plates of orange-red herschelite. Or colorless herschelite, with similar crystals, but also with tiny crystals popping out of the center or near-center of the larger plates like handles, almost at right angles to them. Very quiet white cymbals. The trigonal nature of herschelite shows up in some stubby hexagonal prismatic crystals with trigonal terminations.

What can I not bear to leave out?

The clinoptilolite from Clifton roadcuts in Greenlee County, Arizona. The monoclinic crystals form in packs of plates stacked irregularly, sometimes colorless, sometimes pale yellow. And from Arnett Creek, Pinal County, some water-clear chabazite crystals, and in their midst, a mystery. It is a roundish mass, perhaps chalky white in its underpinnings, but displaying, at the surface, colorless, almost glistening, trigonal points. This is a mineral in search of an X-ray.

From Maricopa, Yavapai, Pinal, and Yuma Counties, Robert Mudra has collected natrolite of the same sparkling quality as the chabazite and the analcime, sometimes extremely slender. Most of it is square or rectangular in cross-section; none of it on my specimens shows the typical prism of the orthorhombic system.

Thomsonite, in a specimen from Arnett Creek, Pinal County, displays some white bow-ties, a little bulging, somewhat lop-sided—must have been quite a party.

Robert Mudra lives at 253 N. 87 Place, Mesa, Arizona 85207. I'm a little uncertain whether he is a dealer or a trader, but he is not listed as a dealer in the Baltimore *International Directory of Micromounters*—so try a trade.

Before going on, let me report that *Micro News and Views,* a quarterly newsletter published by the South African Micromount Society under the editorship of Horst Windisch, 30 van Wouw Street, Groenkloof, Pretoria, South Africa 0181, has a long article in its January issue (1980) by Hugh Heron (my correspondent mentioned above) which describes briefly 14 of the minerals from the Yukon Territory, Canada, gives their chemical formulas and references for further study.

Updating the past: some letters arrived concerning the red plates found with osumilite and hortonolite at the osumilite locality, Obsidian Cliffs, Lane County, Oregon. Hatfield Goudey was good enough to send me a xeroxed copy of the article by Edward Olsen and T. E. Bunch on the "Compositions of Natural Osumilites" from the *American Mineralogist,* **55**, 875 (1970). When osumilite breaks down it goes through a mica phase said by some writers to be biotite, and by Olsen and Bunch (referring to the Obsidian Cliffs material) to be phlogopite. At Obsidian Cliffs, hematite takes over by the leaching of volcanic gases and water, and we end up with the red hematite plates, pseudomorphs after phlogopite. John Lucking, of Escondido Village, Stanford, California, sent me an abstract in English of an article in an Italian journal where osumilite in Sardinia is said to occur in bright black tabular crystals or "in brick-red prismatic crystals almost completely altered into hematite-tridymite." Mike Groben has the "claim" on the osumilite-hortonolite locality in Oregon. He wonders whether the red plates need more work on them.

Mike Groben has his own special taste in micro material. He likes large specimens, 1 by 1 inch to 3 by 3 inches covered with a goodly number of crystals. Excellent specimens like this he is willing to buy "or send good cabinet specimens in return, especially some of the finer and showier zeolites from the region." One of his specimens (from Summit Rock, Klamath County, Oregon) has hypersthene crystals in innumerable tiny vugs, all dark brown, opaque, with the terminations often enough brick-red. One could spend a long time searching the nooks and crannies for other species as well on such a specimen. On a second piece, likewise from Summit Rock, the hypersthene crystals are a beautiful translucent brown and just as plentiful. A clinoptilolite specimen (Yaquina Head near Newport, Oregon) displays the mineral in clumps of clear platy crystals here, there, and everywhere. A specimen with lovely neat rectangular plates of thomsonite has also many clear needles; tiny sparkling crystals of calcite perch on the plates or are pierced by the needles, calcite crystals with more forms than one could dare to name. A stunning specimen. The kind Mike Groben likes, and has to offer. His address: 1590 Olive Barber Road, Coos Bay, Oregon 97420.

A mounting tip for photographers from another member of the "mount-the-micros-on-pedestals-on-wafers" group, from John Ade, of the Earth Science Club of Northern Illinois. He writes that he holds the wafer down in the box with a black paper sleeve, which he makes "by wrapping a narrow strip of black paper twice around a wooden mandrel [the appropriate size of dowel would do]. A tiny dot of white glue at each end of the paper helps to make a sturdy sleeve which slides in with just enough friction to hold the wafer securely." The wafer (along with the specimen, of course) can still be easily removed from the box when necessary by grasping the pedestal with a pair of curved tweezers. John Ade has many good ideas on mounting; I wish I had time to pass along more to you.

Department of Correction

Herb Corbett tells me that the mineral he had considered to be or had been told was fluoborite, and which appeared so named under my photograph for the column in the *Mineralogical Record,* **10**, No. 5, he now knows to be parasepiolite.

The aftermath to George Chao's discovery that Marcelle Weber's so-called star-shaped St. Hilaire muscovite (a silicate) was really manasseite (a complex carbonate) is worth repeating. On being given the recent information, a witty member of the ROM staff regarded the specimen through the microscope, and said calmly, "Well, you can see there's no silicon in there."

And you can see there's no more room down here.

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What's New in Minerals?

DETROIT SHOW 1980

Visitors to the 1980 *Greater Detroit Gem and Mineral Show* were treated to displays mounted by no less than 18 institutions. The two main displays (a sculpture from the Smithsonian and some mastodon bones from the University of Michigan) were not of mineralogical interest, but the others were, by and large, exciting. No central theme served to unify the various displays this year, so I'll not go into detail on their contents. The same may be said of the displays by private collectors (though the case of Michigan copper and silver, including a superb silver in and on calcite displayed by Philip Scalisi, was especially remarkable).

Now to the dealers. *Mineral Kingdom* carried a new discovery from Tsumeb, collected there by a miner in mid-1980: olivenite-cuproadamite in greenish black crystal aggregates to about ½ inch on matrix. Chemical analysis, they said, had shown the specimens to be right at the 50 percent point in the olivenite-cuproadamite series, and the physical characteristics seem to be midway between what is common for the two end-members. Over 100 specimens were collected from a single pocket, including about six good cabinet specimens, six miniatures, and a large number of smaller sizes. Good new material from Tsumeb has appeared with depressing infrequency during the last year or two, and it was therefore encouraging to see this large and interesting lot.

And that was not all from Tsumeb. *Mineral Kingdom* also had about a dozen examples of pale blue willemite pseudomorphs after azurite crystals to 1½ inches. The pseudomorphs were not solidly filled. It appeared as if dolomite crystals had first partly coated the azurite crystals; then the azurite was dissolved away leaving a mold; finally blue willemite crystallized inside the molds as a botryoidal growth not entirely filling them. To top it off, the willemite is brilliantly fluorescent. Along these same lines were about 20 specimens of pale green smithsonite pseudomorphs after azurite crystals to 2 inches, some in cabinet-size groups.

Tony Jones' *California Rock and Mineral Supply*, downstairs in the wholesale section, carried a large stock of the new cinnabar crystals from near Lovelock, Pershing County, Nevada. Most of the specimens show small cavities in matrix with cinnabar crystals to about ⅛ inch perched inside. But a few pictured here (offered in the retail section by John Barlow's *Earth Resources*) reach larger sizes: ½ inch, ¾ inch, and one faceting-grade crystal to about 1 inch! Some of the crystals are absolutely identical in habit and appearance to the premier locality in China. Others are interestingly and strangely varied. All are sharp, lustrous, a brilliant red, and transparent to translucent. This is a locality to watch closely for more and better specimens ranking in the top echelon of the world's minerals. Tony says the claimholders on the locality are currently working very hard to produce more specimens. *Wright's Rock Shop* has been carrying these cinnabars too.

The Demix quarry at Mont St.-Hilaire, Quebec, produced a sizeable pocket of rhodochrosite a few weeks before the show, and these were displayed in a case by the finders, Ernie Schlichter and Larry Venezia (45 Neptune Rd., East Boston, Mass. 02128). More than 40 specimens were recovered, all in thumbnail to miniature sizes, from a vertical pipe 10 inches wide and about 8 feet tall. The crystals are a very dark, blackish red, and reach about 2 inches in size; most are in the ¾ to 1¼-inch range, and many are on matrix. The habit typically consists of the low (flattened) rhombohedron and the basal pinacoid in various combinations. Some crystals show only the rhombohedron, which is very lustrous, and the majority are twinned by a rotation about the *c* axis. The pinacoid or *c* face, however, is frosty, and predominates on some crystals to the extent of making them very thin plates. Prices ranged from $30 to $300. Pocket associations include aegirine, albite, leucophanite, microcline, polylithionite and sphalerite, though few if any of these species were liable to be on any one particular specimen.

Chris Wright of *Wright's Rock Shop* brought a number of interesting items to the show. Perhaps the most amusing was a large group of blackish quartz crystals of the type which many collectors believe to be irradiated. There was no doubt about this particular specimen though . . . a crystal had been broken off prior to irradiation and had not been treated. It was therefore still perfectly clear and colorless, and had been *reattached* to the main specimen! It made quite a display.

Wright also had specimens of pale green botryoidal wavellite from a new locality in Montgomery County, Arkansas (the current miners will divulge no more details on the location). And he has acquired about 100 specimens of pale blue aquamarine from Pakistan (see previous issue). Incidentally, many people are not aware that Wright carries a large stock of top-quality fossils, including large vertebrates and especially skulls.

The show was awash with fine Elmwood mine (Tennessee) specimens this year, and a more detailed description of their discovery by Tom Palmer *(Crystal Cavern Minerals)* is appended to this report. *Roberts' Minerals* carried the largest stock of Palmer material, though specimens in smaller numbers had spread through quite a

Figure 1. **The Light Guard Armory in Detroit, Michigan, where the annual Detroit Show is held.**

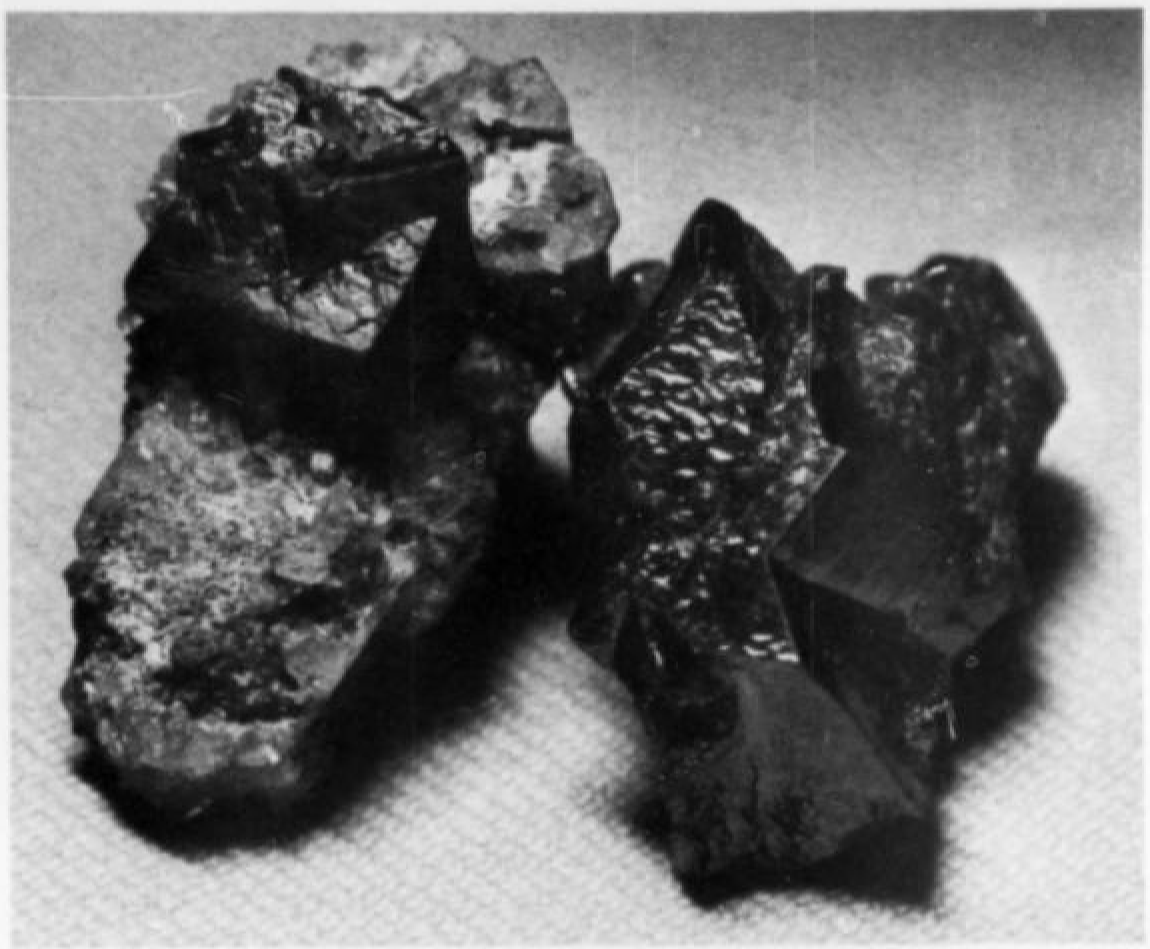

Figure 2. **Cinnabar crystals from near Lovelock, Pershing County, Nevada. The large crystal on the right is 1 inch. John Barlow** ***(Earth Resources)*** **specimens.**

few other dealers by showtime. Palmer brought a portion of his stock to the federation show in Pasadena earlier this year and distributed some then, but the bulk remained at his El Paso quarters and is still being distributed to retail dealers. An independent group, *Middle Tennessee Minerals* (P.O. Box 40, Elmwood, Tenn. 38560), carried a large spread of Elmwood specimens at the show motel. Clearly now is the time to acquire a fine Elmwood calcite, while the selection is the largest it's ever been.

A few years ago (*Record*, 7, 135) we reported on some malachite stalactites from Shaba Province, Zaire (curious readers may want to look that one up, because it contains the only photo ever published in the *Record* of our publisher and former editor, John White). A new batch has recently hit the market, including many in miniature and small cabinet sizes. At the main show these were being sold by *The Miner's Den* (Royal Oak, Mich.), and at the motel they were carried by *Kent South American Diamond Mines* (Southfield, Mich.). New specimens of metatorbernite, sphaerocobaltite, and the largest batch of cuprosklowdowskite I've ever seen were also being offered (same province). Following the show, *Kent's* entire stock of these species was sold to Victor Yount.

Here's the story on the greatest silver find on the Upper Peninsula of Michigan in the last 20 years. A prospector using a metal detector discovered two pockets in a forest in the Eagle River area of Keweenaw County. At least 50 specimens were recovered, up to large cabinets in size. The crystals range from herring-bone to arborescent to sharply cubic in habit, elongated crystals reaching more than an inch. The largest pieces were purchased immediately by a local "investor." The remainder, about 45 smaller pieces ranging from thumbnails to small cabinet size, were offered at the motel show by Don Olson (*Minerals International,* 304 W. Clovernook Lane, Glendale, Wisc. 53217). Many of the small, cubic crystals show a cavernous or hopper growth, and all of these were found in one pocket. The other pocket yielded the arborescent crystals, generally on prehnite.

Figure 3. **Cinnabar twin about $^3/_4$ inch across on dolomite matrix from near Lovelock, Pershing County, Nevada. John Barlow specimen.**

The *Arizona-Sonora Desert Museum* in Tucson sells minerals; many collectors are not aware of this. These sales help to support and enlarge the museum collection by providing funds for purchases. This year the museum offered a recent discovery of pyrite (micro, drusy) coating pyrrhotite crystals of curved, pseudohexagonal pyramid habit. These were found at the Contessa mine, Francisco Portillo, Santa Eulalia district, Chihuahua, Mexico. The pyrrhotite crystals range up to about 1½ inches in length, looking rather like sparkling bear claws or buffalo horns in their proportions. They occur in groups up to cabinet size, though most specimens are smaller. Associations include calcite and sphalerite. The specimens were modestly priced at $5 to $20.

Harvey Gordon of *Wildlife Limited* brought to the show a large lot of spessartine crystals from Ely, Nevada, reddish black trapezohedrons to about ⅓ inch, all on whitish matrix. The crystals occur individually, not in groups as a rule, and all of the specimens consist of a single sharp crystal on matrix. Harvey also brought some interesting azurite groups from LaSal, Utah.

You've been reading in this column about the big strike of vanadinite from near Mibladen, Morocco. It burst forth prolifically at this year's Detroit Show. Many dealers at the main show and at the motel show carried what must have been a total of several hundred specimens. These are arguably the finest Morocco has produced, and it was an opportunity many collectors took advantage of, despite the high prices.

Rare minerals were not lacking either. *Mineralogical Research* offered rare ilvaite crystals from the Cyclades, Greece (where collecting is now prohibited by the government), osumilite from Sardinia, and edingtonite from Golden, British Columbia. George and Susan Robinson had purple vesuvianite from Asbestos, Quebec, and recently identified jamborite from Antwerp, New York.

This year the show committee, in the name of the Friends of Mineralogy, tried something a little different on Saturday night: a mini-symposium dealing with any new or interesting minerals which the dealers (at the main show *and* at the motel show) cared to present. Unlike the Rochester Symposium's half-day treatment of what has been new over the previous year, this mini-symposium dealt primarily with items actually in the dealers' stocks at the show. It was a fine opportunity for the dealers to show off their new material and to convey information in more detail than can be typed on a label. From the viewers' standpoint, it was a good time to see if anything had been missed in looking through the dealers' stocks. Afterwards the audience was invited to comment on the concept. Their reaction was positive, and a number of constructive suggestions were offered. Perhaps this will become a regular feature of the Detroit Show in future years.

W.E.W.

NEW DISCOVERIES AT ELMWOOD, TENNESSEE

During the past six years, Tom Palmer of Crystal Cavern Minerals (El Paso, Texas) has been working with the Jersey Miniere Zinc Company to preserve mineral specimens from their mines in central Tennessee, specifically in the Elmwood area. Recently some major specimen discoveries were made at the Elmwood and Gordonsville Mines.

Jersey Miniere has been operating these mines for the past eight years. During that time, pockets, some quite large, were found which contained fine specimens of calcite associated with fluorite, barite and sphalerite (see W. E. Wilson (1976), *Record,* **7**, 186–187; and L. E. Kearns and H. Campbell (1978), *Record,* **9**, 213–218). Of greatest interest to collectors have been the large, beautifully twinned calcite crystals which range from colorless to a deep reddish amber.

During normal mining operations in the period from April to July, 1980, three major pockets were encountered. These pockets, formed by the dissolution of limestone beds, were lined with large crystals, and the pocket floors were masses of collapse breccia containing crystal-lined voids. Many such pockets are entirely filled with collapse breccia and are mineralized by sphalerite, the main ore mineral. As a result, mining operations tend to seek these zones and mine through them. The three recently found pockets had open spaces 10 to 20 feet long and 2 to 4 feet high. All were lined with spectacular crystals.

Over 3,000 pieces were recovered from these pockets; these range up to 500 pounds each. The proportion of high quality specimens was unusually large.

Each pocket was somewhat different. One produced predominantly small fluorite and sphalerite associated with larger barite clusters. Another contained small, bright, amber-colored calcite twins on dolomite. The third contained large single crystals of calcite associated with fluorite.

Because this is an operating zinc mine, it was necessary that specimens be recovered as promptly as possible to minimize the disruption in mining operations. Palmer and an experienced team of Jersey Miniere mine personnel were brought in, and the easily recoverable specimens were quickly collected and packed. Larger specimens buried under the rubble, were removed with the aid of a small three-wheel tractor. Dolomite breccia fragments weighing up to 1,000 pounds were dragged out of the pockets by the tractor, and into the open mine heading where they could more easily be worked on. More specimens were found in the breccia under the large slabs. After all the specimens were boxed and loaded on the tractor, they were hauled to the main hoisting shaft, where they were raised to the surface 1200 feet above.

Many of the calcite specimens recovered may prove to be the finest ever found, and they certainly rank with the world's best. The scalenohedral calcite twins are commonly called "footballs" in reference to their shape. The crystal faces have mirror-bright luster and sharp edges. The calcites are commonly perched precariously but esthetically on dolomite matrix, and reach over 6 inches in size. Some are associated with fluorite, sphalerite, and barite. One 3-foot slab of dolomite was removed, covered by 40 perfect calcite crystals 2 to 3 inches each.

The remaining portions of the pockets were mined through and destroyed. The material recovered has been undergoing preparation for sale. A portion was shown at the California Federation Show in Pasadena last August; as more material is prepared, collectors and dealers will have the chance to see new material not exhibited at earlier shows.

Unfortunately, due to the poor economic climate existing in the zinc industry today, mining companies have begun closing mines and shafts in the area. By the time this reaches print, only one mine will remain open and will be operated on a reduced scale. This may be the last opportunity to buy quality Elmwood material.

W.E.W. ▨

Underground benching at Stahlberg, Rhennish Prussia, in the 1860's.

From February 1981, I shall be taking a sabbatical year to hunt minerals and write a novel in India. I expect to return in the fall and resume relations with my long suffering, but understanding, friends and clients. I won't have a booth at Detroit or Pasadena in 1981, so my next scheduled show will be Tucson '82. Do, please, reach me in Oakland after September 1981.

Rusty

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This joint symposium of the Mineralogical Society of America — Friends of Mineralogy has now been fully organized. In conjunction with the Tucson Gem and Mineral Show (February 13-15), the 24 speaker program is devoted to all aspects of the genesis of pegmatites and their minerals. Topics to be covered include the minerals of common and rare-earth elements, isotopes, phosphates, the origin of colors in some of these minerals, and detailed descriptions of numerous individual pegmatites world-wide. The program will consist of two series of 12 papers, each 30 minutes in length, designed to be of interest to amateurs and professionals alike. Dr. Clifford Frondel of Harvard University will be the Sunday evening banquet speaker.

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Copper Acetate Hydrate with Native Copper

by **Pete J. Dunn**
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In late 1979, a most uncommon specimen was called to my attention by Brad Van Scriver of *Van Scriver's Minerals.* The specimen is predominantly native copper which is coated with a thin patina of a light to medium blue color. The most interesting aspect of this specimen is the occurrence of an abundance of dark blue crystals, around the base of the specimen, which are partially coated with a thin, porous crust of atacamite, admixed with compounds of indeterminate nature.

The dark blue crystals were the object of immediate attention because of their beautiful color, well-developed euhedral habit, and abundance. The color of the crystals is very similar to that of veszelyite, a deep greenish blue. The lack of cleavage indicated it was not veszelyite and this was confirmed by their lower indices of refraction. An X-ray powder diffraction pattern indicated that these superb blue crystals are copper acetate hydrate, $Cu(CH_3COO)_2 \cdot H_2O$, a compound not known to occur as a mineral. The crystals from the specimen were compared with reagent grade copper acetate hydrate (Fisher Scientific #C-437) and found to be identical in appearance. There exists no doubt as to their identity.

Copper acetate hydrate is also known as natural verdigris, the name of which is derived from *vert de Grece* ("green of Greece") because it was originally used to denote any of the green alteration patinas which occur on bronzes and other statuary. Verdigris has been used as a pigment for quite some time and for those readers interested, an excellent account of its use is given by Gettens and Stout (1966).

Figure 1. **The Van Scriver specimen, 7 cm across, of large copper crystals and small, dark green copper acetate hydrate crystals to 2 mm in size.**

Few acetates are known in the mineral kingdom, and the circumstances surrounding this specimen have raised questions in the mind of the author as to the "naturalness" of the copper acetate hydrate crystals.

The specimen is shown in Figure 1. The copper acetate crystals are all clustered at the base of the crystalline copper matrix, rather than being more randomly distributed over the surface of the specimen. If the copper specimen is placed in an esthetic position, as is shown in the photograph, there appears to be a series of parallel bands of deposition. The topmost half of the specimen is coated with the thin-film or druse of copper acetate hydrate; next there is a layer of copper coated with atacamite, which is in turn followed by the large (up to 2mm) crystals of copper acetate hydrate, followed by a bottom layer of atacamite. This sequence suggests that the specimen may have been immersed in some cleaning solution and remained there as the solution evaporated; the evaporation causing the formation of the different compositional layers. This cannot be proven without extensive testing of different solutions and evaporation rates and sequence of depositions, all of which are beyond the scope of this study.

In addition to the layered appearance and layered depositions, the existence of several insects among the copper acetate hydrate crystals at the "bottom" of the specimen is of interest. (There are two different kinds of dead insects. One was lost in study but preliminary examination indicated that it was a weevil of some sort. The second insect is of the family *nitidulidae,* the sap-beetles.) Two possible interpretations present themselves: (1) the insects were present at the time of crystallization, or (2) the insects chewed their way into the copper acetate hydrate. Stimulating though the latter possibility may be to entomologists, the former is born out by an additional observation. One of the insects clearly has some of the blue patina on its posterior, suggesting that the insect was present during part of the crystallizing process. One could speculate at length as to how the insect got there, how it was coated with the copper acetate, and on and on. I mention this fact only because it is suspicious. The occurrence of large (2 mm), well-formed, euhedral crystals suggests growth of the crystals from solution. Acetates can form from solutions flowing or percolating through wood bearing humic-acids, but I cannot offer a concise explanation of the origin of this specimen.

The unlikeliness of a natural copper acetate, combined with the suspicious nature of the specimen, and the lack of firm documented evidence of its finding (it is reportedly from the Onganja mine, near Seeis in Southwest Africa), combine to suggest that this compound should not be proposed as a mineral species at this time. If the publication of this paper results in the observation of additional occurrences, the provenances of which are adequately documented, then there may be justification for species status for copper acetate hydrate.

This paper is written to document an unusual specimen, in the hope that the information may be of use to mineral scientists, curators, or collectors who encounter similar specimens in the future.

ACKNOWLEDGEMENTS

The author is indebted to Michael Fleischer, Sidney Williams and Mary Mrose for helpful discussions, and to Eugene Jarosevich for procurement of the reagent used for comparison. The study was initiated as a direct result of the insights and curiosity of Brad Van Scriver, to whom I am indebted for an exciting adventure.

REFERENCE

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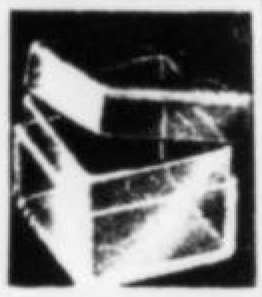

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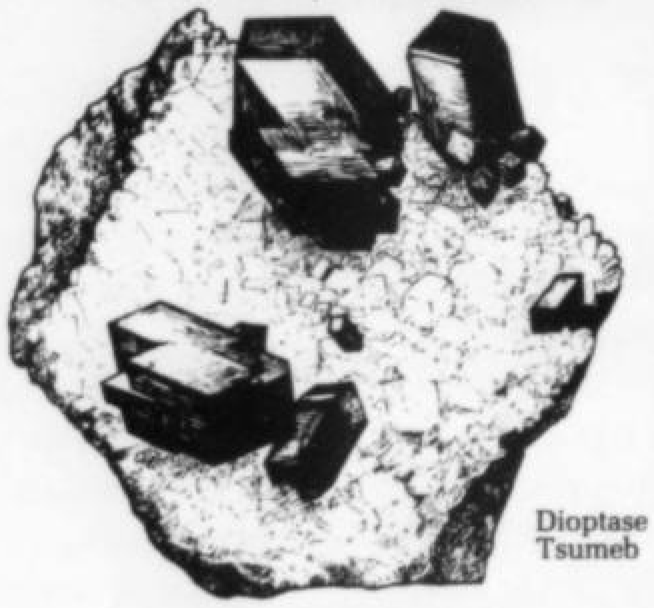

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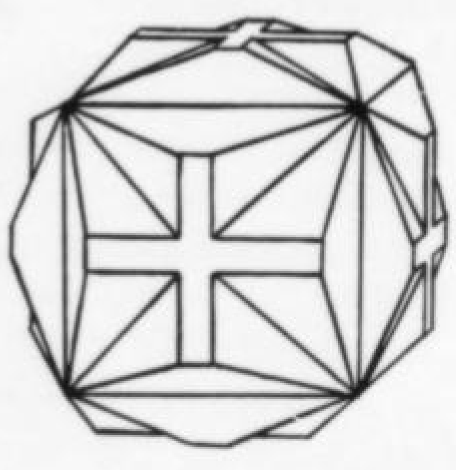

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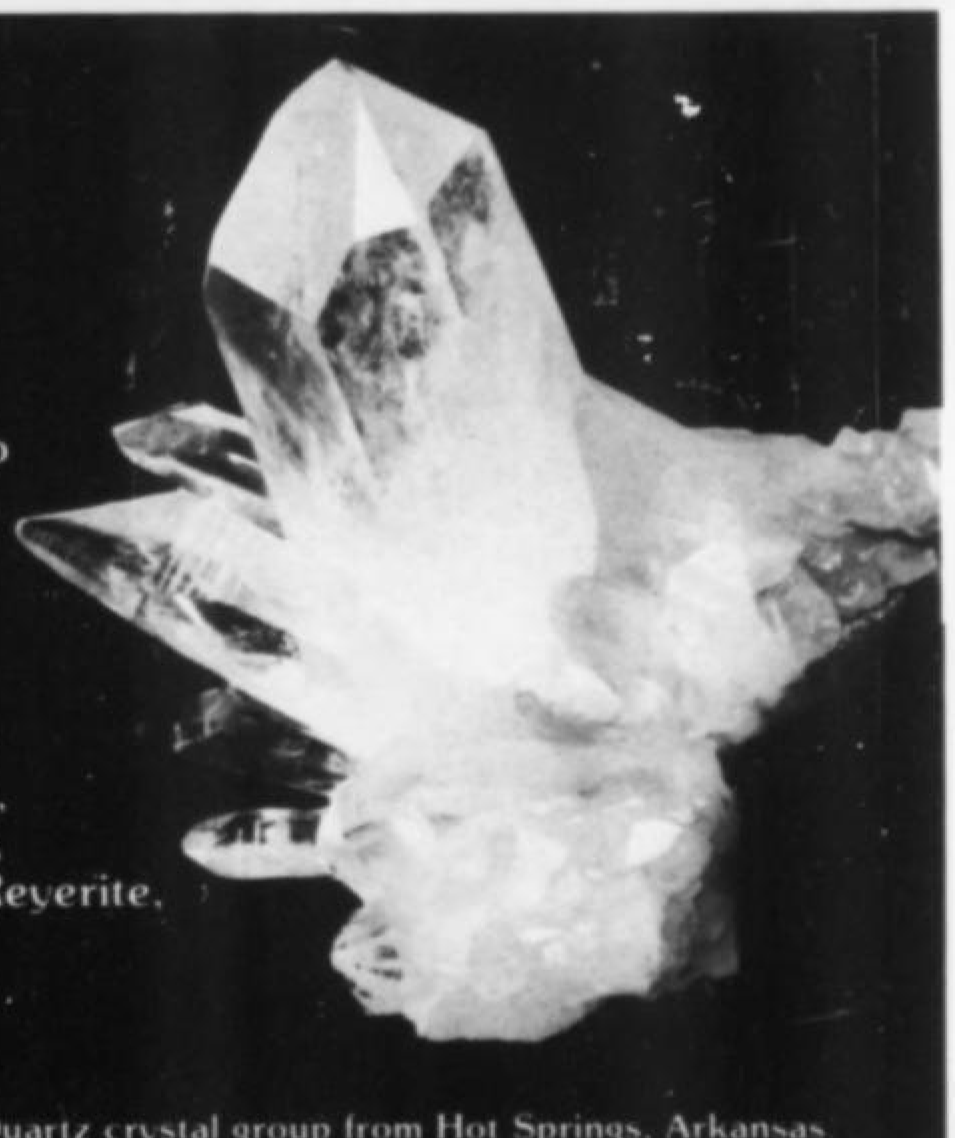

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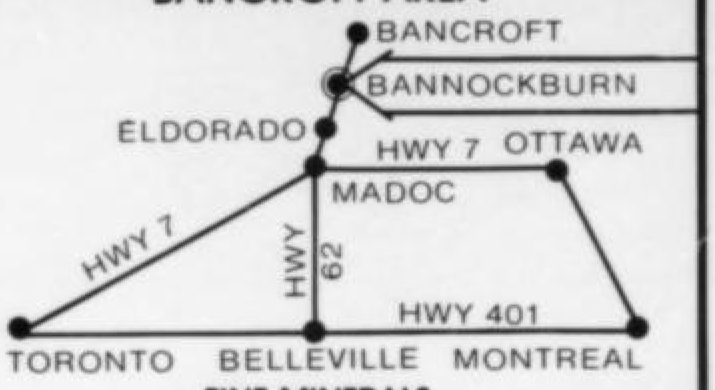

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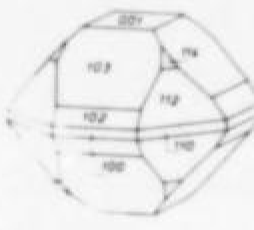

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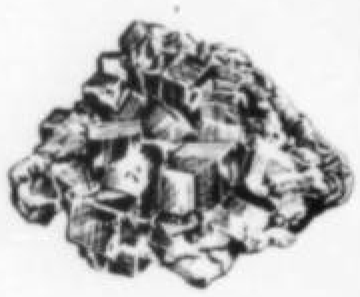

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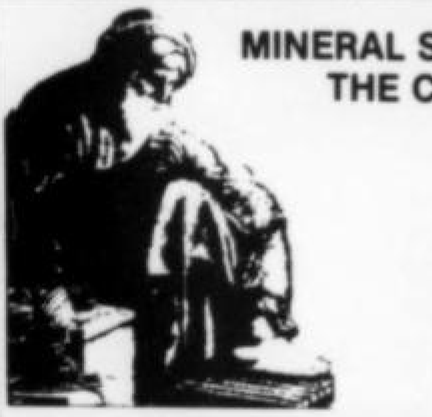

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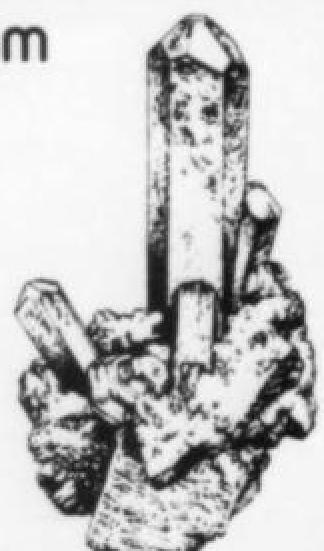

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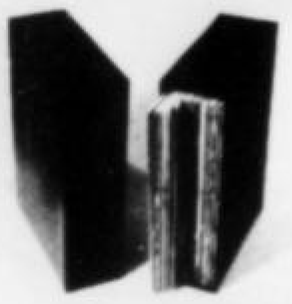

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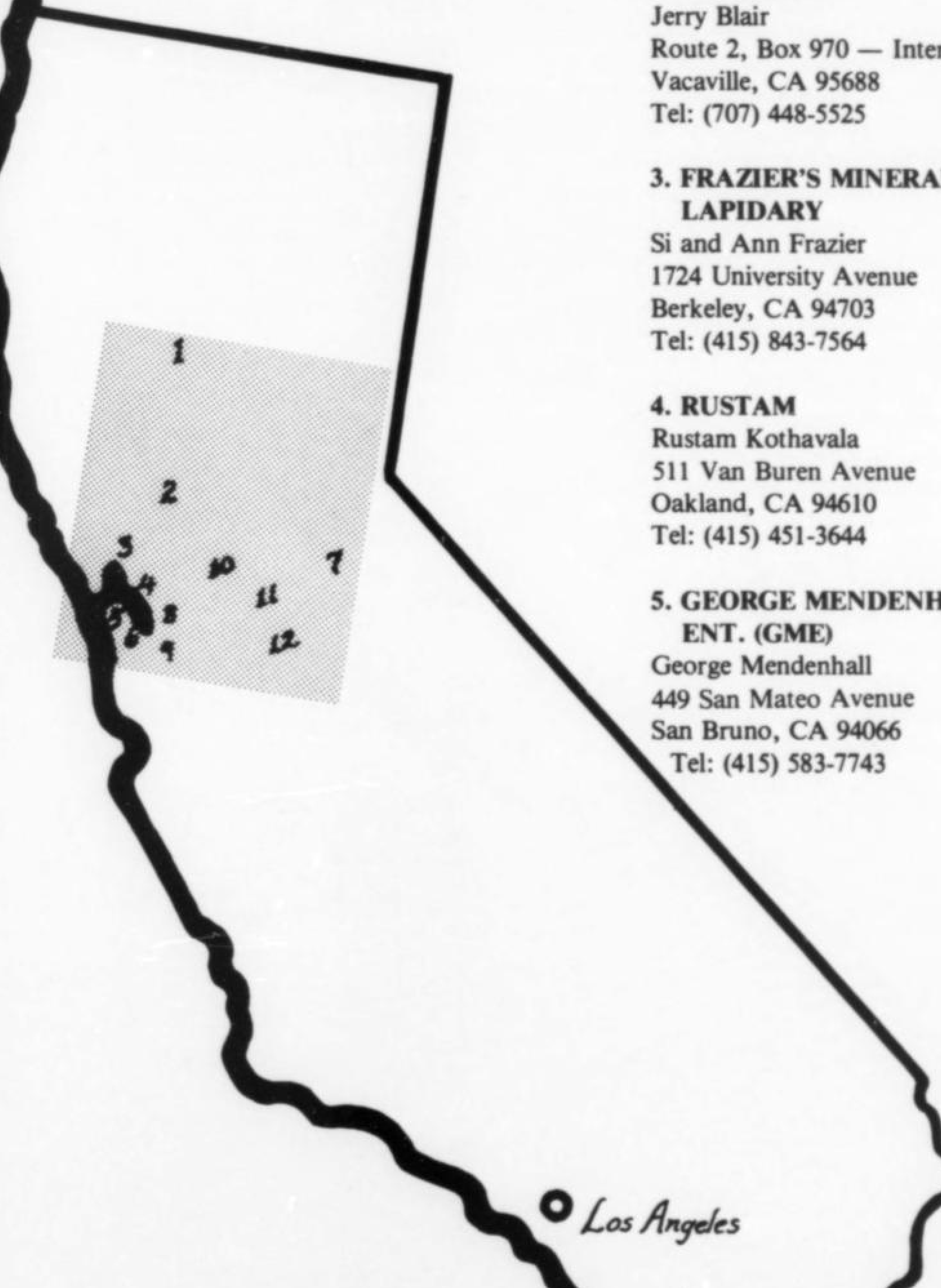

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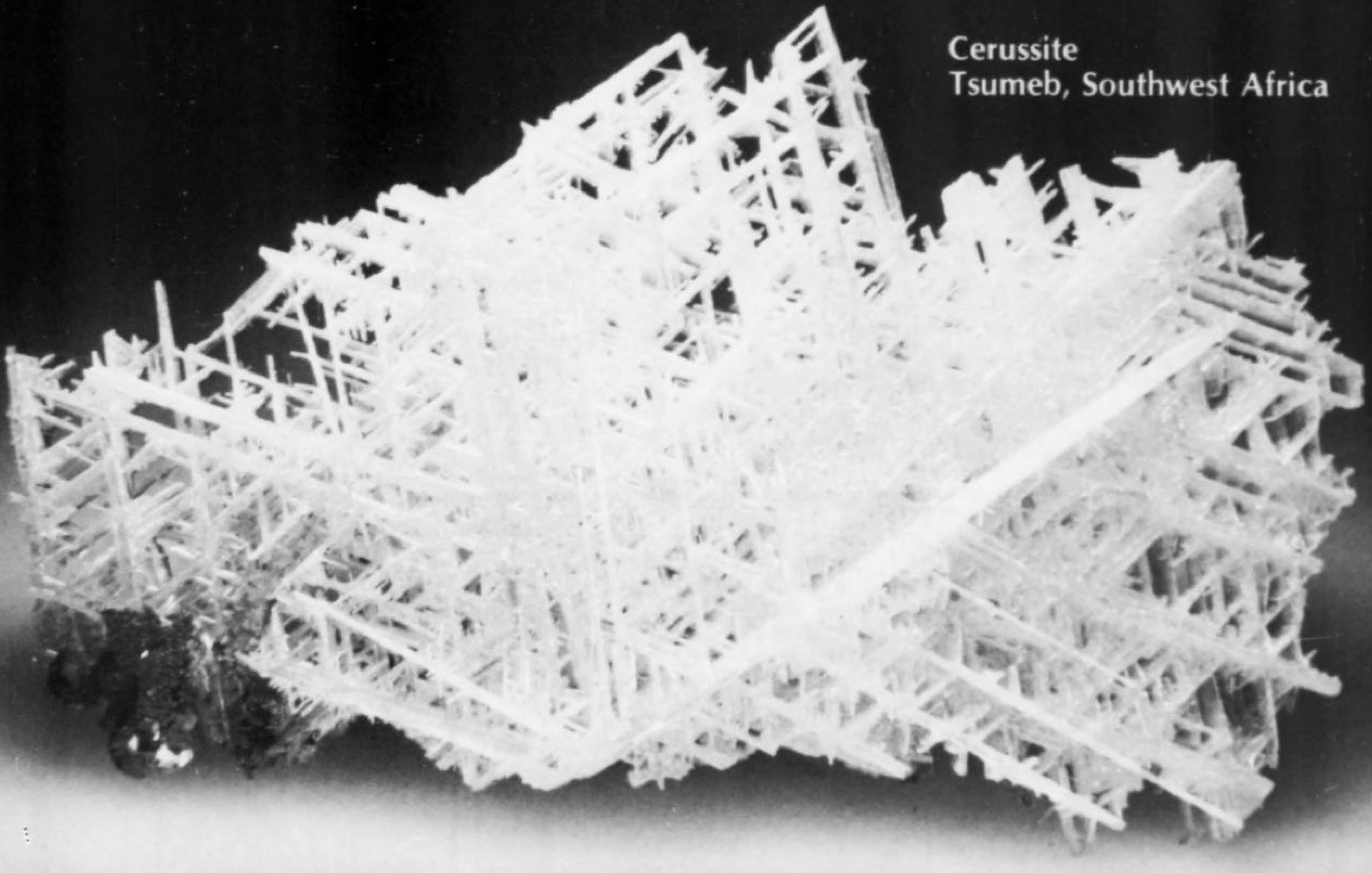

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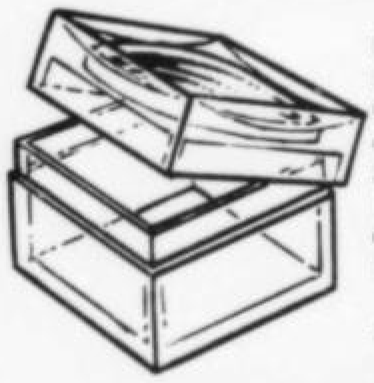

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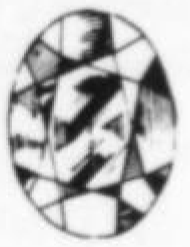

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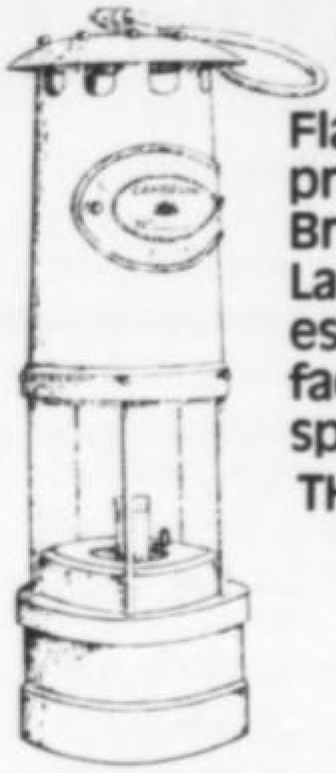

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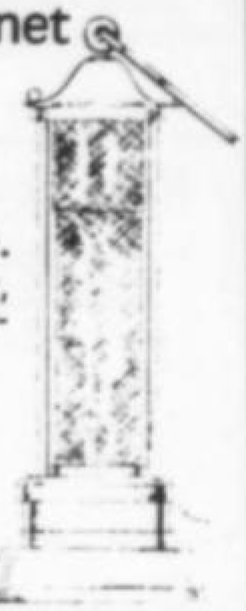

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Additions and Corrections To The *Glossary of Mineral Species, 1980*

by **Michael Fleischer**
Mineral Sciences Department
Smithsonian Institution
Washington, DC 20560

Less than a year has passed since the 1980 Glossary went to press, but it has been a period of unparalleled activity in mineralogical research, including the publication of many new minerals (38 in this list) and of new data on established minerals. It therefore seemed desirable to publish this list of additions and corrections as soon as possible, and it is hoped that new lists can be published annually.

Again many friends have been kind enough to make valuable suggestions and to call my attention to errors. I am deeply grateful to all who have written to me and thank them all, especially Robert Cobban, Jim Ferraiolo, Peter Modreski, Mary E. Mrose, Andrew L. Palmer, and G. W. Shokal.

Introduction, 5th par.—change "now" to "not"
Elements—The symbol for Argon should be Ar

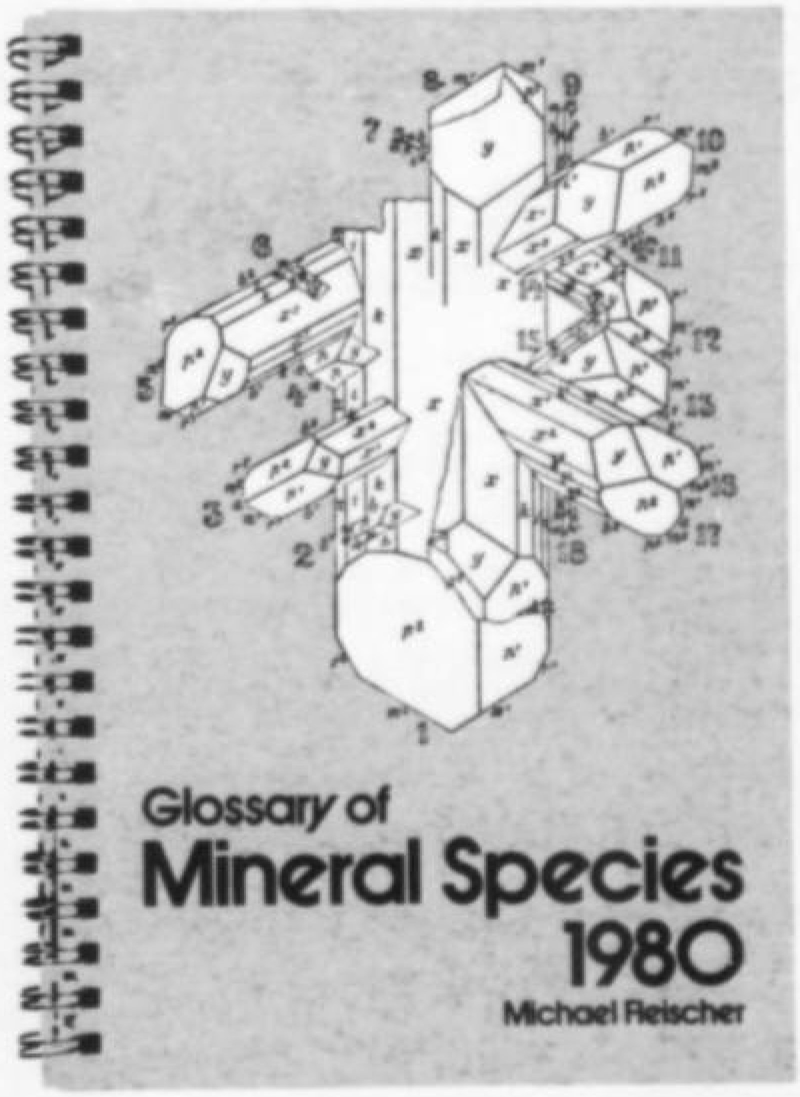
Page

1 Abelsonite prophyrin is misspelled
1 Admontite add "dimorph. with **Mcallisterite**"
3 Albrittonite add "compare **Bischofite, Nickelbischofite**"
4 Alstonite change to "trimorph. with **Barytocalcite** and **Paralstonite**"
4 Althausite add "**65,** 488 (1980)"
5 Amicite add "**65,** 808 (1980)"
6 Anduoite add "**65,** 808 (1980)"
8 Apuanite change formula to $Fe^{+2}Fe_4^{+3}Sb_4^{+3}O_{12}S$
8 Aramayoite formula should read Ag, not Ab
8 Ardennite change formula to $Mn_4(Al,Mg)_6(SiO_4)_2Si_3O_{10}[(As,V)O_4(OH)_6]$
9 Arnimite add "orth."
☐ 10 add "**Ashanite,** $(Nb,Ta,U,Fe,Mn)_4O_8$, orth., compare **Ixiolite**"
13 Barytocalcite change to "trimorph. with **Alstonite** and **Paralstonite**"
15 Beraunite change formula to $Fe^{+2}Fe_5^{+3}(PO_4)_4(OH)_5 \cdot 4H_2O$
17 Bischofite add "compare **Albrittonite**"
☐ 19 add "**Bogdanovite,** $Au_5(Cu,Fe)_3(Te,Pb)_2$, orth. (?), ps. cub., rose-brown to bronze"
19 Borickite add "perhaps = **Delvauxite, 65,** 813 (1980)"
☐ 20 add "**Brabantite,** $CaTh(PO_4)_2$, mon., compare **Cheralite, Monazite**"
20 Braggite add "dimorph. with **Cooperite**"
21 Briartite reference should be 1966
23 Bukovite formula should be $Tl(Cu,Fe)_2Se_2$
23 add "Cadmium, Cd, hex."
26 Carnelian should not be in bold face
27 Caryopilite delete "Kaolinite-Serpentine group," add "related to **Friedelite, 65,** 335–339 (1980)"
27 add "Castaingite, $CuMo_2S_5$ (?), hex., **50,** 264 (1965)"
27 add "Cathophorite, $CaTh(PO_4)_2$ (= **Brabantite** (?))"
29 Chalcomenite add "dimorph. with **Clinochalcomenite**"
29 Chalcophyllite should be in bold face
29 Chalcosine should not be in bold face
29 Chalcothallite change "tet." to "orth., ps. tet."
30 Cheralite add "compare **Brabantite**"
30 Chervetite reference should be 1963
30 Childrenite formula should have $(OH)_2$
☐ 31 add **Chlormanasseite,** $(Mg,Fe^{+2})_5Al_3(OH)_{16}[(Cl,OH,(CO_3)/2]_3 \cdot 3H_2O$, hex., Min. Abs. 31, p. 226 (1980)
32 Chudobaite The formula should have $(AsO_4)_4$
32 Clinobisvanite reference should be **39**
☐ 32 add "**Clinochalcomenite,** $CuSeO_3 \cdot 2H_2O$, mon., blue-green, dimorph. with **Chalcomenite**"
☐ 33 add "**Clinotyrolite,** $Ca_2Cu_9[(As,S)O_4]_4(O,OH)_{10} \cdot 10H_2O$, mon., emerald-green, compare **Tyrolite**"
34 **Cl-tyretskite** should be in bold face
34 Coalingite formula should have (CO_3), not $(Co)_3$
34 Cobalt-zippeite formula should have $16H_2O$
34 Cochromite add "**65,** 811 (1980)"
34 Coconinoite reference should be **51**
35 Cooperite add "dimorph with **Braggite**"
36 Corkite formula should have $PbFe_3^{+3}$
40 Davidite change to "**Davidite,** $(La,Ce)(Y,U,Fe^{+2})(Ti,Fe^{+3})_{20}(O,OH)_{38}$, trig., **Crichtonite** group, **41,** 700–718 (1956), **64,** 1010–1017 (1979)"
☐ 40 add "**Defernite,** $Ca_3(CO_3)(OH,Cl)_4 \cdot H_2O$, orth."
40 Delafossite add "compare **Mcconnellite**"
41 Delvauxite change to "$CaFe_3^{+3}(PO_4,SO_4)_2(OH)_8 \cdot 4{-}6H_2O$ (?), **65,** 813 (1980)"
43 Djerfisherite change formula to $K_6(Cu,Fe,Ni)_{23}S_{26}Cl$, add "compare **Thalfenisite**"
☐ 43 add "**Dorfmanite,** $Na_2HPO_4 \cdot 2H_2O$, orth."
43 Drugmanite add "**65,** 809 (1980)"
45 Ecdemite change formula to $Pb_6As_2O_7Cl_4$
☐ 45 add "**Eifelite,** $K_2Na_4Mg_9Si_{24}O_{60}$, hex., **Osumilite** group"
☐ 47 add "**Erdite,** $NaFeS_2 \cdot 2H_2O$, mon., copper-red, **65,** 509–521 (1980)"
47 Eskimoite formula should have Ag_7
49 Fairbankite add "**65,** 809 (1980)"
49 Fayalite formula should be $Fe_2^{+2}SiO_4$
49 add "Femolite (= ferrian **Molybdenite** (?), **50,** 261 (1965)"
50 Fengluanite add "= **Isomertieite** (?), **65,** 408 (1980)"
☐ 51 add "**Ferripyrophyllite,** $Fe_2^{+3}Si_4O_{10}(OH)_2$, mon., compare **Pyrophyllite**"
52 Ferrohexahydrite is misspelled
53 Ferropumpellyite add "**56,** 2158 (1971)"
53 Ferrowyllieite add **65,** 810–811 (1980)"
☐ 54 add "**Fichtelite,** $C_{19}H_{34}$ (dimethyl-isopropyl-perhydrophenanthrene), orth."
55 Fraipontite reference should be **62**
55 Francoanellite is misspelled
56 Furongite reference should be 425
☐ 57 add "**Gaitite,** $H_2Ca_2Zn(AsO_4)_2(OH)_2$, tric., compare **Talmessite,** Can. Min. **18,** 197–200 (1980)"
57 Galena **Altaite** should be in bold face
58 Geocronite change to "$Pb_{14}(Sb,As)_6S_{23}$, mon., forms a series with **Jordanite, 61,** 963–970 (1976)"
59 Girdite add "**65,** 809 (1980)"
☐ 59 add "**Gittinsite,** $CaZrSi_2O_7$, mon., Can. Min. **18,** 201–203 (1980)"
60 Glaukosphaerite add "compare **Kolwezite**"
62 Grimaldiite add "compare **Heterogenite**"
63 Guanglinite add "= **Isomertieite** (?), **65,** 408 (1980)"
63 Guettardite add "dimorph. with **Twinnite**"
64 Hardystonite delete "dimorph. with **Junitoite**"
64 Harkerite reference should be **37,** 359 (1952)
65 Hatchite add "compare **Wallisite**"
67 Heterogenite add "compare **Grimaldiite**"
67 Hexastibiopanickelite, change to **Hexatestibiopanickelite**
68 Hibonite formula should have O_{19}, not O_{18}
69 Holtedahlite add "**65,** 809–810 (1980)"
69 Hongshiite add "= platinian **Copper** (?), **65,** 408 (1980)"
71 Hydrodelhayelite add "orth."
72 Hydrophilite should not be in bold face, add

"perhaps = **Antarcticite** or **Sinjarite,** Min. Mag. **43,** 682 (1980)"

73 Hypercinnabar reference should be **63,** not **68**
74 Illite delete the asterisk in the formula
74 Imandrite add "**65,** 810 (1980)"
75 Irhtemite formula should be $Ca_4MgH_2(AsO_4)_4 \cdot 4H_2O$
76 Iwakiite add "**65,** 406 (1980)"
76 Ixiolite add "compare **Ashanite**"
77 Jefferisite is misspelled
78 Jordanite change to "$Pb_{14}(As,Sb)_6S_{23}$, mon., forms a series with **Geocronite**"
78 Junitoite change formula to $CaZn_2Si_2O_7 \cdot H_2O$, delete "dimorph. with **Hardystonite**"
79 add "Kamiokite, $Fe_2Mo_3O_8$, hex"
80 Kanonaite is misspelled
80 Kassite reference should be **52**
81 Keckite formula should have $(OH)_3$, not $(OH)_2$
81 Keldyshite formula should be $Na_{2-x}H_xZrSi_2O_7 \cdot nH_2O$
83 add "Kivuite, $(Th,Ca,Pb)H_2(UO_2)_4(PO_4)_2(OH)_8 \cdot 7H_2O$ (?), orth. (?), compare **Phosphuranylite, 44,** 1326 (1959)"
83 Klebelsbergite add "**65,** 499–505 (1980)"
84 Koktaite reference should be **34**
☐ 84 add "**Kolwezite,** $(Cu,Co)_2(CO_3)(OH)_2$, tric., black to beige, compare **Glaukosphaerite, Rosasite, Zincrosasite**"
☐ 84 add "**Kolymite,** Cu_7Hg_6, cub."
☐ 84 add "**Kovdorskite,** $Mg_5(PO_4)_2(CO_3)(OH)_2 \cdot 4H_2O$, mon."
85 Krutovite reference should be to **62**
85 Ktenasite reference should be 381
☐ 85 add "**Kulkeite,** $Mg_8Al(AlSi_7)O_{20}(OH)_{10}$, mon. (interlayered **Talc - Chlorite**)"
85 Kulanite formula should have $(Fe^{+2},Mn,Mg)_2$
86 Kurchatovite change "orth." to "orth. and mon."; formula should be "$Ca(Mg,Mn,Fe^{+2})BO_5$"
86 Kurnakovite formula should be $MgB_3O_3(OH)_5 \cdot 5H_2O$
86 Kurumsakite reference should be 583
86 Kusuite formula should have Ce^{+3}, not Ce^{+4}
87 Landesite reference should be **49,** 1122–1125 (1964)
88 Laueite add "compare **Paravauxite**"
88 Lazurite formula should be $(Na,Ca)_{7-8}(Al,Si)_{12}(O,S)_{24}[(SO_4,Cl_2,(OH)_2]$
90 Leucophoenicite reference should be 1146–1166
91 Liottite formula should be $(Ca,Na,K)_8(Si,Al)_{12}O_{24}(SO_4,CO_3,Cl,OH)_4 \cdot H_2O$
91 Liujinyinite add "**65,** 810 (1980)"
93 Lusungite formula should have Fe_3^{+3}
93 Luzonite reference should be 766-779
93 MacFallite add "**65,** 406 (1980)"
☐ 94 add "**Maghagendorfite,** $NaMn(Mg,Fe^{+2},Fe^{+3})_3(PO_4)_3$, mon., **65,** 810–811 (1980)"
94 Magnesiocarpholite add "**65,** 406 (1980)"
96 Magnesium astrophyllite formula should be $(Na,K)_4Mg_2(Fe^{+2},Mn,Fe^{+3})_5Ti_2Si_8O_{24}(O,OH,F)_7$
96 Magnesium-zippeite formula should have 16 H_2O
97 Manandonite is misspelled
97 Mandarinoite formula should be $Fe_2^{+3}Se_3O_9 \cdot 4H_2O$
97 Manganbelyankinite formula should have $(Ti,Nb)_5$
97 Manganese-shadlunite formula should have (Mn,Pb,Cd)
98 Margarosanite formula should be $Pb(Ca,Mn)_2Si_3O_9$
99 Mariposite Phengite should not be in bold face
99 Maslovite add "**65,** 406–407 (1980)"
100 Mcallisterite add "dimorph. with **Admontite**"
100 Mcconnellite reference should be 593, add "compare **Delafossite**"
100 Mckelveyite reference should be **64,** 659 (1979)
102 Mertieite-I add "**58,** 1–10 (1973)"
102 Mertieite-II change reference to **61,** 1249–1254 (1976)
102 Meta-autunite formula should have $(UO_2)_2$
104 Meta-uranospinite formula should have $(UO_2)_2$
105 Minguzzite formula should have K_3
☐ 105 Minium should be in bold face
105 Minnesotaite formula should have $(Fe^{+2},Mg)_3$
106 Monazite add "compare **Brabantite**"
107 Montdorite reference should be page 1331
☐ 108 add "**Morozevicite,** Pb_3GeS_4, cub., forms a series with **Polkovicite**
108 Mossite should not be in bold face
109 Muscovite formula should be $KAl_2(Si_3Al)O_{10}(OH)_2$
☐ 109 add "**Nacaphite,** $Na_2Ca(PO_4)F$ orth."
110 Na-komarovite formula should be $(Na,Ca,H)_2Nb_2Si_2O_{10}(OH,F)_2 \cdot H_2O$
110 Nasturan Pitchblende should not be in bold face
110 Natrofairchildite add "orth."
110 Natrojarosite formula should have Fe_3^{+3}
☐ 111 add "**Nealite,** $Pb_4Fe^{+2}(AsO_4)_2Cl_4$, tric., orange, Min. Record **11,** 299–301 (1980)"
111 Nenadkevite add "a mixt. of **Uraninite** + **Boltwoodite, 62,** 1261–1262 (1977)"
112 Nichromite add "**65,** 811 (1980)"
112 Nickelbischofite add "compare **Albrittonite**"
112 Nickel-iron add "see also **Tetrataenite**"
112 Nickel-zippeite formula should have 16 H_2O
113 Niobo-zirconolite Zn in formula should be Zr
114 Nolanite add "**52,** 734–743 (1967)"
☐ 114 add "**Nordströmite,** $Pb_3CuBi_7S_{10}Se_4$, mon., **65,** 789–796 (1980)"
114 Nukundamite add "**65,** 407 (1980)"
☐ 114 add "**O'Danielite,** $Na(Zn,Mg)_3H_2(AsO_4)_3$, mon."
☐ 114 add "**Olgite,** $Na(Sr,Ba)PO_4$, hex., blue to bluish-green"
116 Orthochrysotile delete Orthoantigorite
116 Orthoferrosilite **Enstatite** should be in bold face
☐ 119 add "**Paralstonite,** $(Ba,Sr)Ca(CO_3)_2$, trig., trimorph. with **Alstonite** and **Barytocalcite**"
120 Paravauxite change formula to $Fe^{+2}Al_2(PO_4)_2(OH)_2 \cdot 8H_2O$ and add "compare **Laueite**"
122 Permingeatite formula should be Cu_3SbSe_4
123 Petscheckite is misspelled
124 Phosphuranylite add "compare Kivuite"
124 add "Pianlinite, $Al_2Si_2O_6(OH)_2$"
☐ 126 add "**Polkovicite,** $(Fe,Pb)_3(Ge,Fe)S_4$, cub., forms a series with **Morozevicite**"
127 Priorite **Aeschynite-(Y)** is misspelled
128 Pumpellyite add "**61,** 176–177 (1976)"
☐ 128 add "**Putoranite,** $Cu_{16-18}(Fe,Ni)_{18-19}S_{32}$, cub."
129 Pyroaurite is misspelled
129 Pyrophyllite add "compare **Ferripyrophyllite**"
130 Queitite add "**65,** 407 (1980)"
130 Rancieite, reference should be **54,** 1741–1742 (1969).
131 Ranunculite add "**65,** 407 (1980)"
☐ 134 add "**Rokuhnite,** $Fe^{+2}Cl_2 \cdot 2H_2O$, mon."
134 Rosasite add "compare **Kolwezite**"
134 Roscoelite formula should have $(OH)_2$
135 Rosemaryite add "**65,** 811 (1980)"
135 Roweite formula should have Mn_2
135 Rustenburgite reference should be **61,** 340 (1976)
136 Sabinaite formula should have Na_9Zr_4
137 Sahlite should not be in bold face
139 Scarbroite formula perhaps $Al_5(OH)_{13}(CO_3) \cdot 5H_2O$, Min. Mag. **43,** 615–618 (1980)
☐ 140 add "**Schieffelinite,** $Pb(Te,S)O_4 \cdot H_2O$, orth., Min. Mag. **43,** 771–773 (1980)"

140 Schmeiderite name should be **Schmiederite,** Min. Mag. **43,** 824 (1980)
141 Schuetteite is misspelled
142 Sengierite change orth. to mon., formula changed to $Cu_2(UO_2)_2(VO_4)_2(OH)_2 \cdot 6H_2O$
143 add "Sergeevite, $Ca_2Mg_{11}(CO_3)_{13-x}(HCO_3)_x(OH)_x \cdot (10-x)H_2O$ (?), trig. (perhaps = **Huntite** (?)"
143 add "Shubnikovite, $Cu_8Ca_2(AsO_4)_6Cl(OH) \cdot 7H_2O$ (?), orth. (?), light blue, **40,** 552 (1955)"
144 Sigloite formula should have $(O,OH)_2$
144 Silver change to "**Silver (Silver-3C),** Ag, cub."
☐ 144 add "**Silver-2H, Silver-4H,** Ag, hex."
148 Staringite add "x ‹1, compare **Tapiolite**"
152 Sulvanite **Arsenosulvanite** is misspelled
☐ 152 add "**Sundiusite,** $Pb_{10}(SO_4)Cl_2O_8$, mon., **65,** 506–508 (1980)"
154 Talmessite add "compare **Gaitite**"
☐ 154 add "**Tancoite,** $HNa_2LiAl(PO_4)_2(OH)$, orth., Can. Min. **18,** 185–190 (1980)"
154 Tapiolite add "compare **Staringite**"
154 Taramellite change to "$Ba_4(Fe^{+3},Ti,Fe^{+2},Mg,V)_4B_2Si_6O_{29}Cl$, orth., **44,** 469 (1959), **65,** 123–128 (1980)"
154 Tarnowitzite add "syn. Tarnowskite"
155 Telargpalite formula should be $(Pd,Ag)_{4-x}Te$
☐ 156 add "**Tetrataenite,** FeNi, tet., **65,** 624–630 (1980)"
156 Thalcusite formula should be $Tl(Cu,Fe)_2S_2$
☐ 156 add "**Thalfenisite,** $Tl_6(Fe,Ni,Cu)_{25}S_{26}Cl$, cub., compare **Djerfisherite**"
158 Tirodite formula should have Mn_2^{+2}
☐ 158 add "**Tisinalite,** $Na_3H_3(Mn,Ca,Fe)TiSi_6(O,OH)_{18} \cdot 2H_2O$, trig., yellow-orange, **Lovozerite** group"
159 Tombarthite reference should be 1969
159 Tomichite add "**65,** 811 (1980)"
159 Tranquillityite change to "$Fe_8^{+2}(Zr,Y)_2Ti_3Si_3O_{24}$, hex., **58,** 140 (1973)"
162 Twinnite add "dimorph. with **Guettardite**"
162 Tyrolite add "compare **Clinotyrolite**"
163 Umohoite change "mon." to "mon. and orth."
163 Uralborite add "dimorph. with **Vimsite**"
163 Uralite Amphibole is misspelled
164 Uranopilite reference should be 950–959
165 Vanuranylite formula should be $(H_3O,Ba,Ca,K)_{1.6}$
167 Vigezzite add "**65,** 811–812 (1980)"
☐ 167 add "**Viitaniemiite,** $Na(Ca,Mn^{+2})Al(PO_4)(F,OH)_3$, mon."
167 Vimsite add "dimorph. with **Uralborite**"
167 add "Violan, a violet var. of **Pyroxene, 65,** 813 (1980)"
168 Vitusite add "**65,** 812 (1980)"
169 Wallisite add "compare **Hatchite**"
169 Walpurgite formula should be $(BiO)_4(UO_2)(AsO_4)_2 \cdot 3H_2O$
169 Warikahnite add "**65,** 408 (1980)"
172 Winstanleyite add "**65,** 809 (1980)"
173 Wyartite formula should have Ca_3
173 Wyllieite add "**65,** 810–811 (1980)"
174 Yeatmanite formula should have Mn_7Zn_8; add "**65,** 196–199 (1980)"
174 Yedlinite formula should have $(O,OH)_8$
174 add "Yixunite, PtIn (?) (= indian **Platinum** (?)), cub., **61,** 185–186 (1976), **65,** 408 (1980)"
☐ 174 add "**Yttrobetafite,** $(Y,U,Ce)_2(Ti,Nb,Ta)_2O_6(OH)$, cub., **Pyrochlore** group, **49,** 440 (1964), **62,** 403–410 (1977)"
175 Zemannite formula should have $(Te^{+4}O_3)_3$
176 Zincrosasite add "compare **Kolwezite**"
176 Zinc-zippeite formula should have 16 H_2O
178 Amphibole group add **Magnesio-ferri-katophorite**
180 Bjarebyite group should read "triclinic and monoclinic phosphates"
182 Crichtonite group add **Davidite**
184 Kaolinite-Serpentine group delete **Caryopilite**
185 Linnaeite group second line should be "X = S, Se"
185 Lovozerite group add **Tisinalite**
186 Mica group add **Bityite**
187 Osumilite group add **Eifelite**



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