Examining 120-year old Zeiss Apochromats

I was delighted to acquire on e-Bay a Carl Zeiss Stand IIa complete with case, lock and key, including 3 apochromats and 6 compensating eyepieces "as is" for a reasonable, i.e. for me affordable price.
The stand IIa # 21869 dated 1892 is heavily corroded, not much of the original lacquer being left, and in need of thorough restoration. Mechanically it is in remarkably good condition. However, when I examined the objectives I was stunned, all my hopes for a fine set of excellent objectives dashed in an instant! All three apochromats were beyond repair: Although not so engraved, according to the accompanying canisters, they were apochromat 16mm, 8mm, and 4mm. Closer examination revealed that the inner uppermost lens of each objective had a white crystallized deposit which could not be scraped off (with a wood or copper tool) without leaving a deep scar on the glass surface. It was obvious that the glass itself had "chemically" deteriorated under some climatic influence such as humidity.
As for the apochromats themselves, these are the details:

4.0 mm	Apert. O.95	Tubusl. 160mm	#1429	(180 Marks)* with cover glass correction
8.0 mm	Apert. 0.65	Tubusl. 160mm		(130 Marks)*
16.0mm	Apert. 0.30	Tubusl. 160mm		(100 Marks)*

These objectives were also offered in the English 250mm tube length.
*According to my 1891 catalogue the entire stand IIa with condensor alone cost 290 Marks, the triple revolving nosepiece 27 Marks. The average annual pay of a skilled worker at the time was ca. 1500 Marks).
In 1886 Schott & Gen, Glasstechnical Laboratory published their first catalogue with the new types of glass which Ernst Abbe needed for the computation of his new apochromatic objectives. Prof. Ernst Abbe introduced his latest development which he termed "Apochromats" during a lecture at the Jena Society of Medicine and Natural Science on July 1886. Conforming to their philosophy Zeiss never patented the new glass types or the new apochromatic objectives, leaving the door open to anyone to copy or improve on them.
In his first efforts Abbe had used natural calcium fluoride (CaF_2) but switched later on to glass melts containing fluoride. Some of the problems encountered with the new glasses become clear (no pun intended!) when you read the following excerpt.

I am reminded of a paragraph in a *Supplement to the Catalogue Nr. 28 "Mikroskope und mikroskopische Hilfsapparate" 1890:*
(Please note that it is partly written in the first person!)
"Haltbarkeit der Apochromate" (Durability of Apochromats)
"Furthermore I would like to use this opportunity to reduce to a reasonable level the rumours circulating in the public regarding the durability of the apochromats.
As is only natural with a new product, we were not successful in all aspects of our first tests. Some of our first apochromats (but by far the fewest!) experienced some internal glass deterioration without external visible damage. The glass became turbid, the image fuzzy, the objective unuseable. It turned out that some types of glass used in these systems – despite several tests in the laboratory – did not stand up in practical use.
Surely we cannot be blamed for such individual misfortunes in a totally new field. We endeavoured to compensate any customer by exchanging without hesitation any optical system which showed such deterioration for a new one with more durable glass. Once it was established that certain types of glass showed unusual lack of durability we redesigned all apochromats and replaced those glasses with ones of notably better durability.
*How long these new glasses will remain clear cannot be said with certainty a priori. We can only assure you that according to their chemical composition we can expect a higher resistance against climatic, thermal, and chemical influences and can state that till now i.e within the past 5 years **, no further complaints of defects under normal use have reached us.*
Of course, in the long run even these new glasses may deteriorate. In our moderate climate they have proven excellent. In the tropics, particularly where there is high humidity, we have to advise against the use of these apochromats. In such climates where the atmosphere tends to have unusual highly aggressive activity, possibly no glass at all can remain clear for ever.

It goes without saying that we accept full responsibility for any defect or damage of these lenses – as of all our instruments – so far as we are at fault." (Translation by author)
** This was written in 1890, yet Abbe introduced the first problematic apochromats only in 1886.

Judging by the heavily corroded objective mounts, a thick, coarse layer that can be scraped off, and by the stand itself, the instrument must have been subjected to some rather unfavourable conditions. No wonder the lenses have deteriorated. I have another apo 4.0mm almost identical, serial number 4693 and already engraved with the Carl Zeiss lens logo, which shows similar, although not so drastic deterioration in form of fungus in an internal lens surface. Outwardly it is in very good shape.

So far so good, but I doubt that Carl Zeiss would honour – or can be expected to honour - such a guarantee after 120 years! For me it means that I shall have a beautiful but optically totally useless showpiece, and an example of the influence of time and climate on what we often assume to be inert, unchangeable glass. It was, after all, the observation of chemically corroded glass that brought S. Smakula in 1935 to invent the anti-reflex coating (a few years before the American J. Strong). And we understand better why some crystal or other glassware turns white or turbid in the dishwasher under the influence of the detergents.

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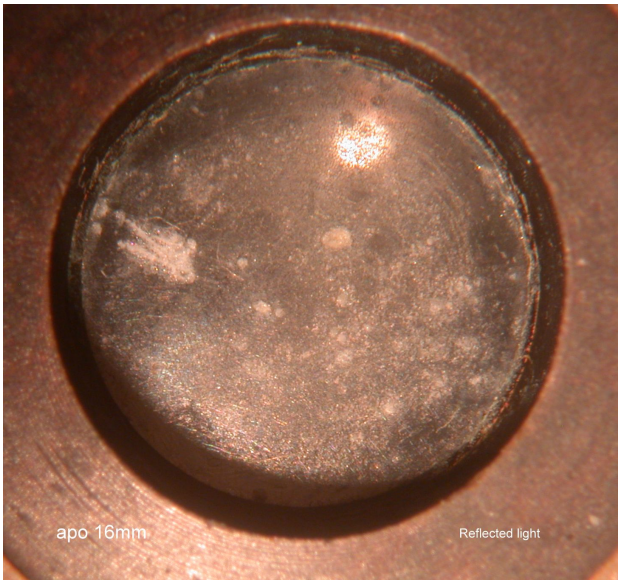
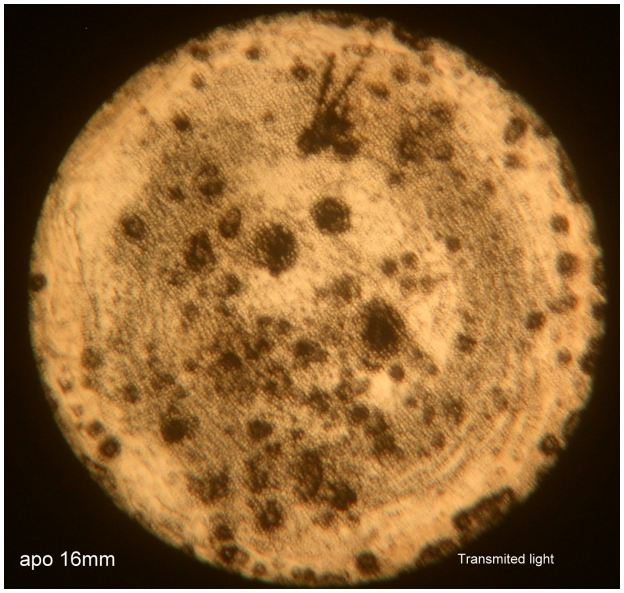

apo 16mm
Reflected light


apo 16mm
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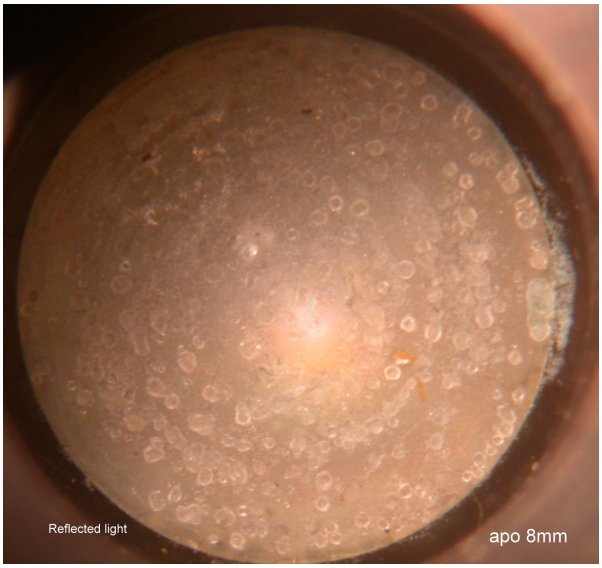
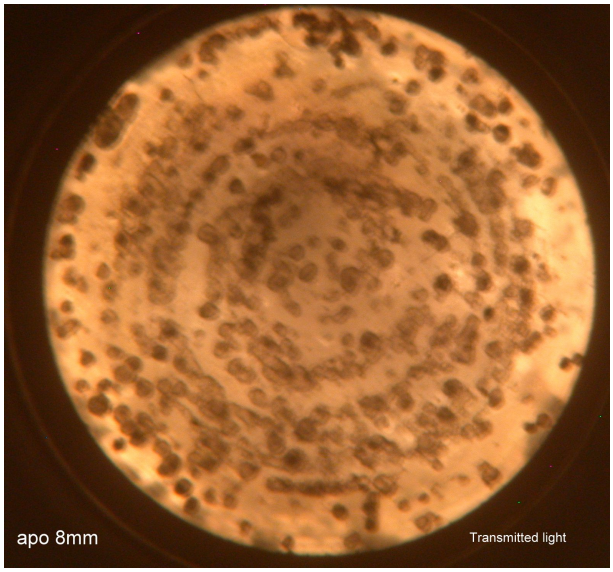
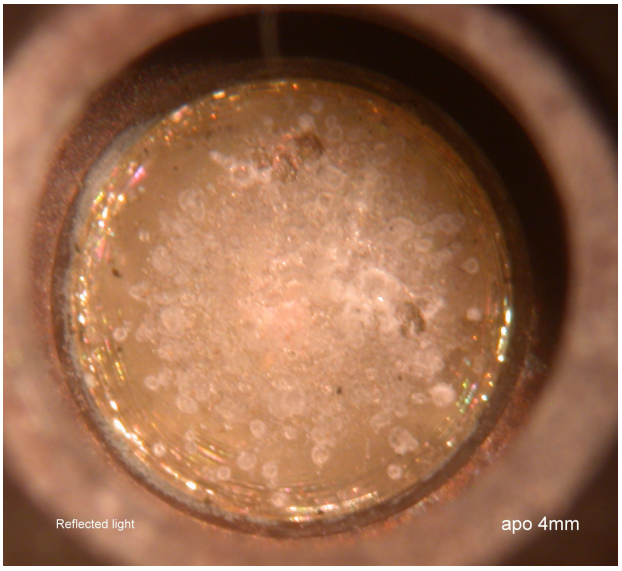
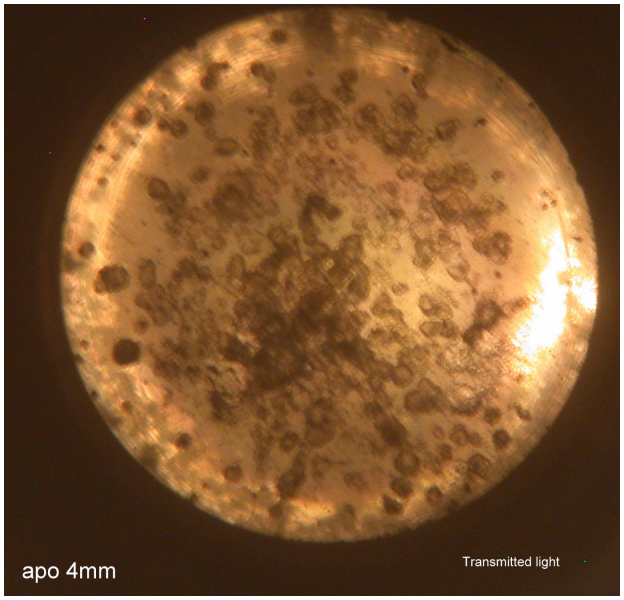

Reflected light
apo 8mm


apo 8mm
Transmitted light


Reflected light
apo 4mm


apo 4mm
Transmitted light