account is meant to serve as a contact point for all problems, questions and requests related to the ESO-MPI 2.2m, the Danish 1.54 m and the ESO 1.52 m telescopes. Support will also be available for the Dutch 90 cm and the ESO 50 cm telescopes. In the future it is foreseen to implement automatic forwarding to this account from the WWW ESO pages.

The Quality of the 3.6m main mirror

A. GILLIOTTE

With this note, a brief history of the 3.6 m main mirror is given, together with a summary of the actions that have been and will be taken to better understand the problems affecting this unit.

The 3.6 m main mirror is made with cemented hexagons of fused silica. On top of these hexagons, a layer of silica is deposited. During the first polishing phase, this layer had to be re-manufactured because it was originally too thin. Early after the installation of the mirror at the telescope, during 1976, a few "white frosted stains" were noticed on the main mirror surface. The evolution of these surface defects has been analysed during each aluminisation. Over the last ten years, the mirror was aluminised during 1985, 1988, 1990 and 1994... During the 1985 aluminisation, recording of the surface defects started, by producing manual maps of the surface. This recording can be done only during the aluminisation period because the fresh aluminium and the absence of dust allows a precise recognition of the surface structures.

This operation was refined during the following 1988 aluminisation with a mapping done under stronger illumination. With this technique, all kinds of defects such as scratches, cleaning stains, aluminium projections and "frosted zones" can be well resolved and mapped in detail. Following the results of this first detailed mapping, attempts were made to contact the main mirror manufacturing company in 1989, unfortunately, with no success. The same procedure was applied (under the same conditions) after 1988 and the evolution of the defects was described in the aluminisation reports of 1988, 1990 and 1994.

In Figures 1 and 2, the maps of the 3.6 m main mirror, as recorded in 1988 and 1994, are presented. The comparison between these maps show the evolution of the blemishes in the last 6 years. During these years some new frosted zones close to the mirror center, affecting less than 0.2 percent of the mirror area, appeared. Please note that, due to the manual design of the maps, the maps give a picture which appears worse than in reality. This is due to the fact that all the defects are drawn with the same intensity, regardless of their true effect. Figure 3 shows a picture of a small affected area (also indicated in Figure 1) with a frosted zone and spots, which appear as white regions. The size of the larger frosted stain is 70mm. Despite the low contribution of these defects to the overall telescope efficiency (see below), it was decided to establish a diagnostic of the mirror "illness", in the framework of the 3.6 m + CAT Upgrade Plan.

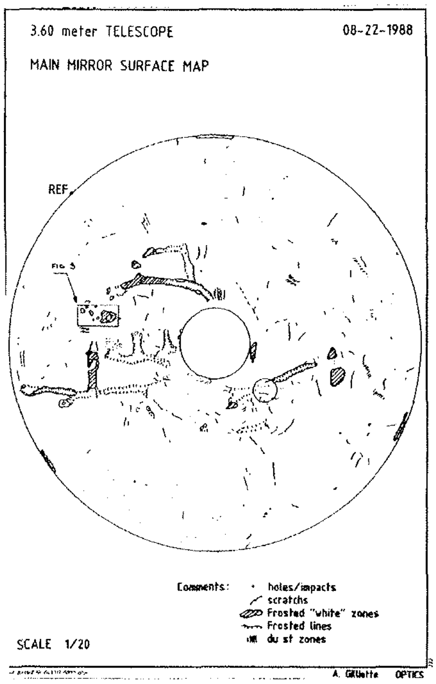

Figure 1.

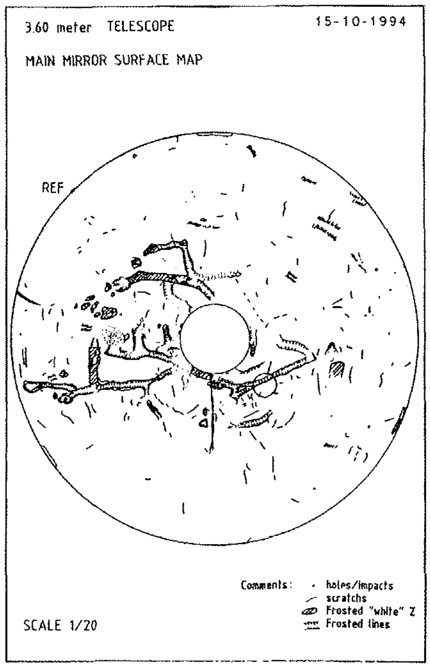

Figure 2.

During the last aluminisation qualification of the frosted zones began, using both magnified surface images and the measured reflectivity of the affected areas. In Figure 4, the transition area between a frosted spot and a sound zone is shown. The spot appears in black and the magnification of the picture is 135, giving a spot diameter of about 0.5 mm. A grain structure is easily visible, with a grain size of about 3 microns.

How do these defects affect observations?

After a fresh aluminisation the reflectivity at 670 nm varies from 89% for for sound areas to 82% for the frosted ones. The rugosity (a measure of the roughness), which is 15 Å for an excellent mirror, varies from 60 Å in good zone to 140 Å in an affected one. Dust on the mirror produces a similar roughness of about 120 Å. The zones affected by the defects cover only 2% of the whole mirror surface. The contribution of the defects on the overall telescope efficiency is negligible, in comparison to that produced by dust.

IR observers may be concerned by the influence of the surface blemishes on emissivity. Emissivity is regularly monitored at 10 μm, and no enhancement has been recorded in the last few years. In fact the measurements show a decreasing trend of emissivity with time, probably due to the CO_2 cleaning procedures that were adopted in the last few years. This shows that emissivity is largely dominated by dust.

Future Steps

Contacts have been successfully reestablished with both the manufacturing and polishing companies. It was found

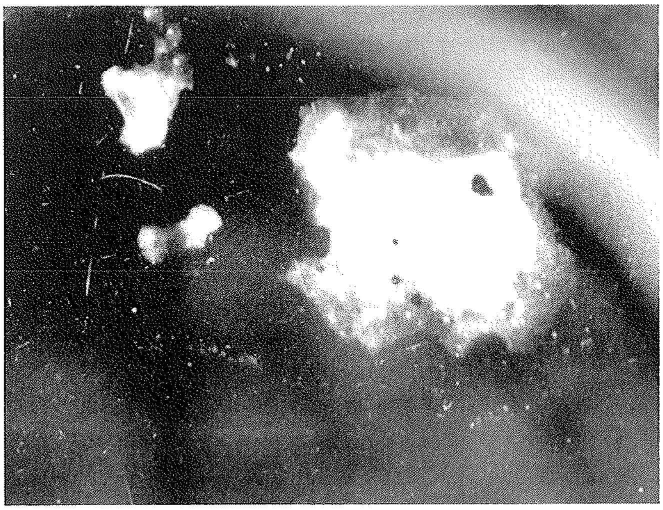

Figure 3.

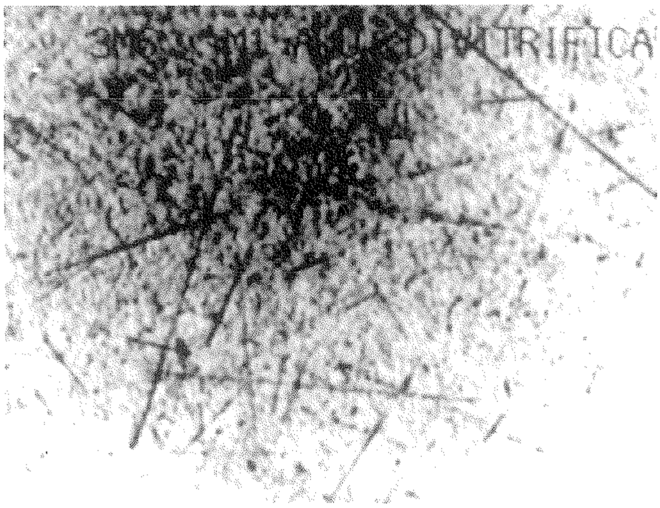

Figure 4.

that no other mirrors having the same characteristics as the 3.6m main are in use. This implies that no direct comparison can be performed. In addition, it has emerged that, due to the manufacturing and polishing history of the mirror, some parts it may be sensitive to particular chemicals.

The next aluminisation of the 3.6m main mirror is anticipated during June 1996. The frosted areas will be analyzed with higher precision. Specific instrumentation will be used to characterise the degradation process:

- A phase contrast microscope will be provided by REOSC and used to figure out the depth of the defects. This instrument is also used to characterise the VLT mirror surface quality.
- An Atomic Scale Tribometer will be also used to map precisely the surface with a very high resolution.
- Surface images with a magnification of 270 will help detail the grain structure.
- Following the results of these tests a small sample of one of the affected zones will be sent for a chemical analysis. A sample from the mirror bottom has been already analyzed and it will be used for comparison. The results show that the sample is almost pure silica with only 0.1% in an amorphous phase.

Even if the slow evolution of the 3.6m main mirror defects does not suggest a dramatic impact on telescope performance in the coming years, in order to obtain full control of telescope quality, the degradation process must be understood.

The Aluminisation of the Main Mirrors

The La Silla Optics Support Team

During period 55, the main mirrors of the 1.5m, 1m, CAT, 90cm Dutch and 1.54m Danish telescopes were successfully aluminised. The reflectivity of the fresh aluminium was measured to be around 90% at 670nm. A surface quality study was initiated to determine the evolution of the mirror surface quality. Magnified images and rugosity measurements of the surface have been obtained for each mirror. The rugosity ranges from 15 Å for the best mirror to 40 Å for the poorest. Dust will, after one year, increase this number to around 120 Å producing both light diffusion and an increase in the emissivity.

The aluminisations were performed with the small aluminisation plant located within the 1.5m telescope building. This plant was refurbished completely by La Silla staff to solve the poor adherence of the aluminium layer. A LN_2 trap was added between the chamber and the oil diffusion pump to stop the oil backstreaming towards the aluminising chamber. The glow discharge cathode was also modified to increase the size of the plasma within the chamber. The good adherence of the aluminium has met the objectives of this plant improvement.

A new cleaning method called "Peel-Off" was successfully tested. A peel off lacquer has been developed by a chemical company in Germany in close collaboration with a staff member at ESO Garching. The efficiency of this cleaning is very good as both the reflectivity and rugosity reach 95% of the values reached after a fresh aluminisation. A program to monitor the time dependent adherence of the aluminium will start soon. It is hoped that this technique will reduce the number of risky mirror handling operations.

Meanwhile, CO_2 snow flake techniques are used to maintain the mirror reflectivity within an acceptable range. The frequency of the cleaning is still under study, but it seems that the dust conditions at La Silla will force us to clean every two weeks. The recently deposited dust must be removed before it sticks. Unfortunately, this method of cleaning must be avoided during conditions of high humidity. These conditions are common during the Chilean summer, so the mirror reflectivity decreases beyond the restoring powers of the CO_2 snow flake technique. This would be a good period for the promising peel off techniques to be applied.

The aluminisation plant for the larger mirrors was also recently refurbished by VTD, a German vacuum company. The 2.2m main mirror aluminisation is scheduled for April '96, while the 3.6m aluminisation is scheduled for June '96 (see article by Alain Gilliotte). The NTT mirrors will be aluminised during the coming "big bang" period, after June '96.