ESO Site Testing in South Africa

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Introduction

The European Southern Observatory (ESO) celebrates 50 years this year. Quoting from their website: "It all began in 1962 [on 5 October] with the signing of the ESO Convention — the culmination of the dream of leading astronomers from five European countries, Belgium, France, Germany, the Netherlands and Sweden." However, seven years of history, all involving South Africa, were excluded from this celebration.

When Errol Swanepoel first contacted me, enquiring about the activities at Zeekoegat near Prince Albert in the Karoo (see article on p.246), all I could tell him was that it was related to site testing done by ESO in the 1950s, before they eventually decided on South America. My main source of information was a paragraph from Moore and Collins (1977), stating that in 1955 five European countries set up two "pilot" observatories; one manned by the French at Zeekoegat and one by the Germans in the Nieuwveld Mountains near Beaufort West. The book continued by saying that the German station soon closed down whereas Zeekoegat continued for longer. The activities were supposedly no more than site testing. Moore and Collins concluded that South Africa was abandoned for reasons mainly unconnected with science, i.e. political ones.

As Errol indicated in his article, Adriaan Blaauw's historical series in *The Messenger* on the founding of ESO is a great source of information (Blaauw 1988, 1989-1, 1989-2). I subsequently studied it with interest and set off on a "virtual tour", using Google Earth, trying to find their observing sites and looking for any remaining evidence. I also scrutinised the SAAO archives which contains some information on this venture, in particular the early days while the British were still part of the original ESO setup.

Blaauw (1988, 1989-1, 1989-2) contradicts Moore and Collins (1977), revealing that Zeekoegat became more than just a test site, but an actual working observatory, and that La Silla turned out to be a superior site, hence the final choice. It also became apparent that an immense amount of effort, lasting more than seven years, covering huge parts of South Africa, was spent before the final decision was made. And that the final decision had been quite a rapid one.

Regarding the influence of politics on the outcome, Blaauw (1989-2) wrote as follows: "Political concern, although undeniable over the years of ESO's activities in South Africa, never became the dominant element in the considerations with regard to the choice of the site; the decision eventually made was a clear-cut one, based on the superiority of the South American findings."

Fig. 1: The effective beginning of ESO, when on 21 June 1953, during a conference at Leiden Observatory, a group of astronomers discussed the idea of a joint European effort in astronomy. From left to right: V Kourganoff (France), JH Oort (Netherlands) and H Spencer (Great Britain). Credit: ESO, A Blaauw

Ont signé:

Prof. O. Heckmann
Directeur de l'Observatoire de Hambourg

Prof. A. Unsöld
Directeur de l'Observatoire de Kiel

Dr. P. Bourgeois
Directeur de l'Observatoire royal de Belgique

Dr A. Couder
Astronome de l'Observatoire de Paris

Prof. A. Danjon
Directeur de l'Observatoire de Paris

Prof. R. O. Redman
Directeur de l'Observatoire de Cambridge

Prof. J. H. Oort
Directeur de l'Observatoire de Leyde

Prof. P. Th. Oosterhoff
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Directeur de l'Observatoire d'Uppsala

Fig. 2: On 26 January 1954, astronomers from six European countries gathered in the stately Senate Room of Leiden University for a discussion of the recently suggested Joint European Observatory. Under the chairmanship of Bertil Lindblad of Saltsjobaden they formulated and duly signed this historic statement, meant to strengthen their efforts for government support in the respective countries. Credit: ESO

The initial JESO concept

It is interesting that the idea of a joint European effort for a southern observatory came from an American-based astronomer whose roots were in Europe. Walter Baade of the Mount Wilson and Palomar Observatories suggested the idea to Jan Oort while spending two months at Leiden Observatory in the spring of 1953. Oort was very keen on the idea and acted swiftly, arranging a discussion meeting the day before the Groningen conference later that year (Fig.1). This was followed up six months later with a watershed meeting, held on 26 January 1954, where twelve leading astronomers from six European countries issued the historical statement which set the scene for what would become the European Southern Observatory (Fig.2). Until October 1956, the original name of JESO (Joint European Southern Observatory) was used. The countries represented were Belgium, France, West Germany, Sweden, the Netherlands and Great Britain. The latter officially withdrew in October 1956 to pursue the idea of a Commonwealth telescope in Australia. (Fig.3)

Also interesting is that, from the onset, South Africa was regarded as the default location – no other country was even considered or discussed. South Africa seemed the obvious choice since, at the time several European countries had facilities here. Examples of these were Harvard Observatory's Boyden Station near Bloemfontein and Leiden Observatory's southern station, first at the Union Observatory in Johannesburg and later at a field station near the Hartebeespoort dam. British astronomy of course had long and close relations with South Africa through the Royal Observatory in Cape Town and the Radcliffe Observatory at Pretoria. Rather than enlarging these existing observatories, the idea was to pool efforts and resources into one large facility. South Africa was the obvious location because it had the best astronomical climate known at the time.

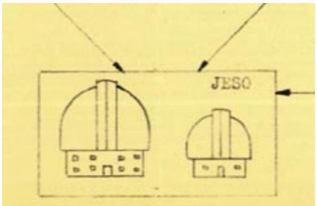


Fig. 3: This sketch was part of an early organogram, showing the original name of JESO (Joint European Southern Observatory). Source: SAAO Archives.

Site options

The newly formed JESO Committee wasted no time and the main agenda item at their next meeting, held in November 1954 in Paris, was to plan site testing in South Africa. They observed that, at the time, all the major observatories in South Africa were located near cities (the Royal Observatory near Cape Town, the Union Observatory near Johannesburg, the Radcliffe near Pretoria and the Lamont-Hussey and Boyden at Bloemfontein). Even though light pollution was not yet regarded as such a threat, the vicinity of a major centre of civilisation was not deemed an important criterion. Weather patterns were studied, but the awareness that an astronomical observatory must also have good seeing was already well understood at the time, though site testing techniques were still very rudimentary. Even though observatories had been operating for many years in South Africa, there was surprisingly little seeing information available for study. Of interest was a 1953 report by BJ Bok where he compared seeing conditions at Boyden to an observing station in Massachusetts. In this Bok pointed out a trend that, all over the High Veld, the seeing tended to deteriorate after midnight with no recovery by dawn. This behaviour was also reported at the Union and Radcliffe Observatories on the reef as well as the Lamont-Hussey in Bloemfontein. (Blaauw, A, 1989-1)

Meteorological data suggested that the Highveld should present the most favourable over-all conditions. It was therefore decided to first explore the Pretoria-Johannesburg and Bloemfontein-Kimberley areas with limited tests in the Beaufort West region further south. At the first two areas, a fixed observatory served as a reference and its results were compared to those from a movable telescope. In these comparative seeing tests the Radcliffe Observatory in Pretoria and the Boyden near Bloemfontein played major roles. The Royal Observatory in the Cape was similarly involved, although not as much, being situated in a different climatic zone.

Initially the sites explored were just slightly elevated from the surrounding terrain. Towards the end, the "mountain-top" concept (following the Californian experience) was also explored. Thus two different philosophies were looked into.

Seeing testing options

A decision that had to be made was on the exact manner in which the seeing should be tested. At the time, three methods were common practice:

1) Diffraction ring appearance, where the observer judged the seeing by the appearance and quality of the diffraction rings of highly magnified stellar images, using a small reflecting telescope. A disadvantage of this method was that it was difficult to place a quantitative value on the seeing. This method therefore relied on a mutually agreed scale of ratings which needed to be cross-checked regularly between observers.

2) Image motion, where the observer judged the seeing by the degree of movement of the bright central spot of a stellar image. This method allowed a quantitative measurement, for instance the average deviation of the central spot from its mean position. It had the disadvantage of requiring a very stable mount and an accurate telescope drive. However, there were ways around this, like superimposing the views from two adjacent telescopes.

3) Turbulent cells in the atmosphere could be measured directly by means of very fine temperature measurements at a fixed point above ground level (for instance on the top of a long fixed pole). The rapid temperature fluctuations caused by the successive passages of turbulent cells were found to correlate closely with changes in seeing.

The classical method of diffraction ring appearance (method 1) was selected for site testing in South Africa. Four azimuthally mounted reflectors of 250mm aperture were specially built for the project at the Paris Observatory. These were referred

Fig. 4: A typical ESO site testing station in 1961. On the right is the 25-cm Danjou-telescope, used to measure the seeing, while the little photometer on the left is monitoring the transparency of the atmosphere. Credit: ESO, W Schlosser

to as "Danjon telescopes" and were based on the design and method described by Danjon and Couder in their 1935 textbook *Lunettes et Télescopes* (Fig.4). (Telescope makers may recognise influences of Jean Texereau in the design. It was therefore not too surprising to see his name in the correspondence regarding the telescope design.) In addition, atmospheric extinction measurements were required for which photo-electric observations at 4500 and 5300 Å were made, using small refractors (Fig.5).

Fig. 5: This picture shows the observing post on the Rooiberg hill near Cillitzdorp in the southern Karroo, with a Danjon telescope equipped with a Walraven refractor-photometer. The car is one of the two Ford Range Wagons used by the parties. The picture was taken by one of the principal participants of these site tests, J Dommanget. Credit: ESO, J Dommanget

Towards the end of the project, temperature measurements of turbulent cells (method 3) were employed as an alternative method of site validation.

Short runs of image motion measurements (method 2) were also made at the end of the campaign for comparison with site testing undertaken by the Americans in Chile using their favoured method.

Throughout each night of the site-testing campaign four types of observations were undertaken:

1. Visual measurements of turbulence (diffraction rings and chromatic scintillation).
2. Photoelectric extinction measurements (made with long time constants).
3. Photoelectric scintillation measurements.
4. Daily meteorological observations. (ESO Committee, 1956)

The site testing campaign

The map in Fig.6 gives an overview of the huge effort put into testing different sites throughout South Africa during the campaign which lasted from December 1955 to mid-1963, a period of almost eight years. The first, truly representative European party of four young astronomers, from France, Belgium, West Germany and the Netherlands left Holland in October 1955 by boat. Quite fittingly, they travelled on board the *Zuiderkruis* (Southern Cross), the constellation still prominent in the ESO logo today. On their arrival in Cape Town on 6 November 1955, the party was

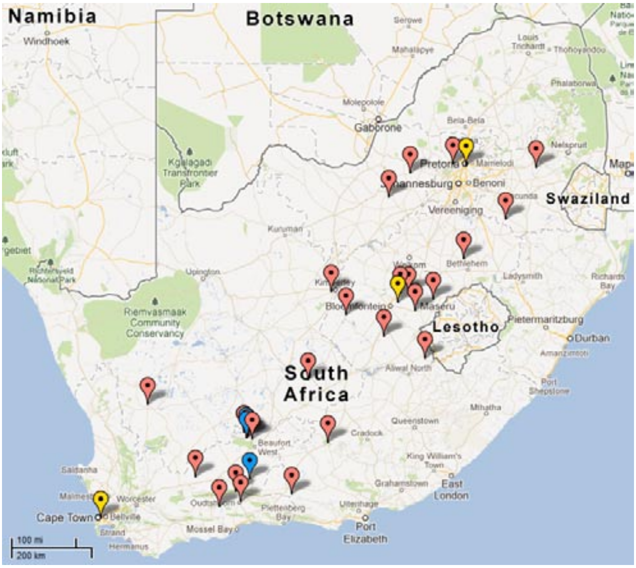


Fig. 6: A map of South Africa marked with the positions of all the testing stations available from the documentation in the SAAO archives. The three yellow pins indicate the existing observatories used for comparison. The blue pins marked the sites that were found to be the best. Source: www.aardvarkmap.net/map/DTSPMO8A where you will be able to browse, zoom and pan into this map.

met by Dr Stoy from the Cape Observatory who had already arranged for them the purchase of two Ford Range Wagons. They wasted no time in getting set up and made their first observations for intercomparing the observers in the Bloemfontein area in December 1955.

Initially the site testing was concentrated on the northern parts of the country. The work was divided into two regions; a northern area covering Johannesburg-Pretoria and a central one, around Bloemfontein. The northern region used the Radcliffe Observatory for comparison and included places such as the Hartebeestpoortdam, Belfast, Koster, Doringbult and Standerton. The Bloemfontein area, with Boyden as its reference, involved Kimberley, Bethlehem, Verkeerdevlei, Clocolan, Tabanchu, Koffiefontein, Edenburg, Zastron and De Aar. (Danjon 1956)

In April 1956 it was decided to drop the Pretoria area and to concentrate on the Free State and expand further southward down to the Oudshoorn region. As testing progressed, the Karoo started emerging more and more as the most promising region, so it was decided to extend testing to there. In particular, around Zeekoegat (near Prince Albert), which is on a low plateau at 1 000 m elevation, amongst the foothills of the Swartberg mountain range. This search covered the Graaff-Reinet and Beaufort West areas as well as the towns of Calvinia (Hantamsberg area), Laingsburg, Willomore, Calitzdorp (Rooiberg area) and included the Swartberg Pass itself. (Boulon et al, 1956)

In February 1957 it was decided to discontinue photoelectric observations until further notice. This was partly because the

Fig. 9: The farm Klawervlei in 1959 against the backdrop of Table Mountain, one of their principal test sites. While testing in the area, they stayed in one of the buildings on the farm. Credit ESO, A Blaauw

Fig. 8: (left) The other temporary observatory on Rockdale Mountain housed a telescope for measuring photometric extinction. From left to right are B van Geelen, H Lindén and André Muller. Source: Blaauw (1991)

results thus far indicated that the extinction in all possible parts of South Africa was fairly close to the expected limit and that variations from place to place were without significance in the choice of possible sites for an observatory. (ESO Seeing Expedition, 1957) It was later resumed during the final comprehensive campaign (Fig.8).

Zeekoegat began to emerge as the superior site by September 1957, with Tafelkopje, a hill near Bloemfontein, a close second. By doing simultaneous testing from Boyden hill, comparing it to measurements taken at different heights up Tafelkopje (which is slightly higher than Boyden), the dreaded inversion layer phenomenon that increased as the night wore on, as reported by Bok, could be verified. (ESO Report, 1957)

The Karoo is the best

By May 1959 it was decided to stop all testing around the Bloemfontein area and to concentrate on Zeekoegat, but attention was also to be given to sites at considerably higher elevations than those explored so far. Such sites were to be found on the Nieuwveld plateau, north-west of Beaufort West. Here three mountain spots on the farm Klawervlei were identified, namely Table Mountain (1 970 m), Rockdale Mountain (1 860 m) and Flathill (1 490 m), which became the subject of intensive tests (Fig.9).

All the sites tested thus far could be reached by existing roads – they would often just set up a station in a clearing next to the road (Fig.10). The Klawervlei mountain sites however required road construction. Through an intermediary of the owner, R Köster, by September 1959, four-wheel-drive access to Table Mountain became possible after the construction of 11 km road. A three-month “quick look” expedition revealed that the seeing on Table Mountain was sufficiently encouraging to warrant more thorough testing. The two other Klawervlei sites (Rockdale and Flathill)

Fig. 10: (left) This picture was taken by one of the principal participants of these site tests, J Dommanget, and shows his collaborator J Boulon, at Willomore, with the equipment as it was moved in Ford Range Wagon between different observing sites. Credit: ESO, J Dommanget

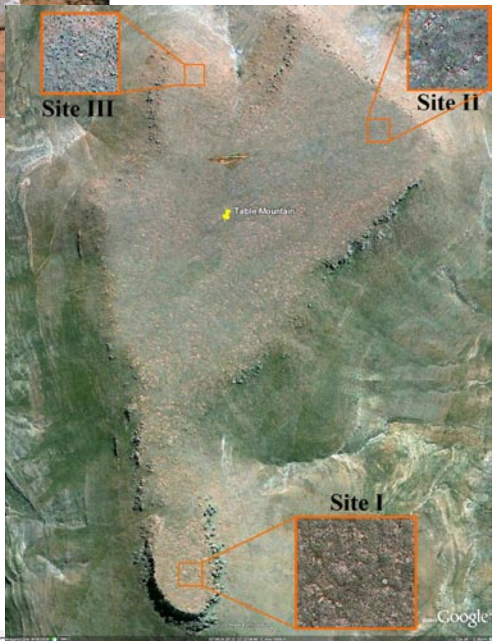


Fig. 11: (below) A map detailing the test sites around Beaufort West marked with crosses, with Zeekoegat towards the south and the three Klawervlei sites NW on the Nieuwveld plateau. The blow-up of Table Mountain shows the three sites investigated by the "quick look" expedition in early 1961 as well as the route taken by the access roads. Credit: Blaauw 1989-1

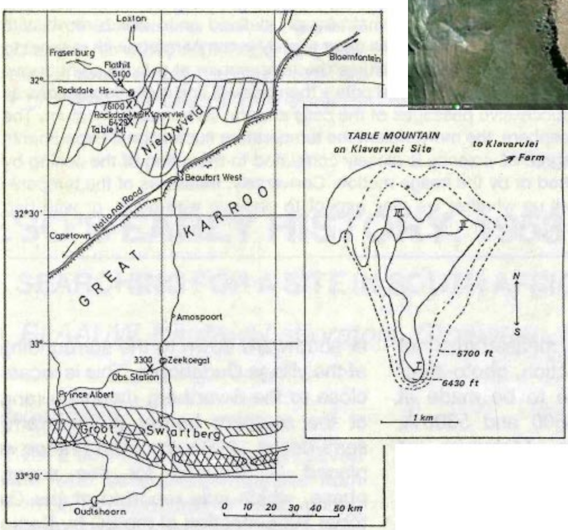


Fig. 12: (above) A Google Earth image of Table Mountain shows the resemblance to the insert map of Fig. 11. Remarkably, the 4x4 trails are still clearly visible after 50 years as well as evidence of the site testing, particularly Site I where they spent more time where the round rondavel foundation seems visible. Credit: Google Earth

Fig. 13: Ample use was made of "rondavel"-type of temporary buildings which could easily be erected and broken down again, particularly handy in the mountainous terrain of the Nieuwveld plateau. Credit: ESO, J Doornenbal

Fig. 14: (below) The GPO (Grand Prisme Objectif Telescope), here at La Silla in 1968, first operated in Zeekoegat, South Africa from 1961 to 1966. The GPO is a copy of a telescope installed at the Observatoire de Haute Provence in France. One half of the telescope is a 40-centimetre objective prism for obtaining the spectra of many objects at the same time. The other telescope is for guiding. Credit: ESO

offered somewhat different characteristics, also worth exploring. Of the three sites on Table Mountain, only the southern one (Site 1 in Figs. 11 & 12) was to be kept. As testing progressed, Flathill seemed to emerge as the most favourable Klawervlei site. As the other two were about equal in quality it was eventually decided to lower the priority on Rockdale Mountain.

Final comprehensive and focussed programme

With site testing efforts now converging on four possible sites (Zeekoegat, Table Mountain, Rockdale and Flathill) in 1961 a final comprehensive programme was launched, covering a full year. This was in fact only concluded in 1963 as it eventually involved more than just site testing, but also "real astronomy" as well as some miscellaneous experiments.

As early as July 1958, suggestions were made to site a southern equivalent of the **Marseilles GPO** (Grand Prism Objectif) telescope in South Africa. This was a 40 cm aperture objective prism refractor for determining radial velocities, directed by Ch. Fehrenbach of the Marseilles Observatory in France. It was a duplicate of a similar telescope installed in the Haute-Provence Observatory (HPO), consisting of a photographic and a visual tube, each of 4 metre focal length (Fig. 14). The French

Fig. 15: The Zeekoevlei site was dominated by the cylindrical domed building of the Objective Prism Astrograph with the rest of buildings consisting of housing and an office. Credit: ESO 1965 Annual Report

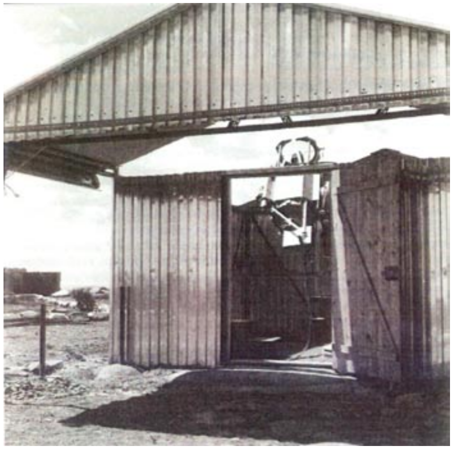


Fig. 16: (right) The 40-cm Tübingen telescope, seen here in its temporary roll-off-roff observatory on Rockdale Mountain, was used for stellar photometry as well as integrated light from the Milky Way. Source: Blaauw (1991).

authorities seemed to be rather uninterested in the whole campaign, so the GPO project was seen as a good opportunity to promote French interest in ESO. It was decided to site the GPO at Zeekoegat (Fig. 15). Construction started in 1958 and it became fully operational by the middle of 1961. This project eventually ran until 1966 (long after ESO "abandoned" South Africa) and was then relocated to La Silla where it was eventually decommissioned in 1996.

Rockdale mountain was selected as the site for the **Tübingen Photometric Project** which ran from August 1961 to November 1962. This consisted of a 40-cm telescope fitted with a three-colour photometer (Fig. 16). Apart from stellar work, it also did surface photometry of the Milky Way and of the Zodiacal Light in blue and red. These observations would become part of the data later used by the site-selection committee.

With the writing on the wall by March 1963, the emphasis of the work shifted towards inter-comparisons between the Danjon telescope and the American **double-beam telemeter** tests in the Andes. This was a special instrument with two objectives about 2 m apart, that formed two images of the same star in a common eyepiece. The relative motion between the two images was a measure of the seeing conditions in a telescope of large aperture (Voigt 1963). For comparison, a telemeter was shipped to South Africa. Likewise, a Danjon telescope was sent to South America. Danjon tel-

Fig. 17: One of the Danjon telescopes, taken in 1962 during the last stages of site testing, here fitted with a mask to simulate a double beam telescope for measuring image motion. Credit ESO, D Beintema

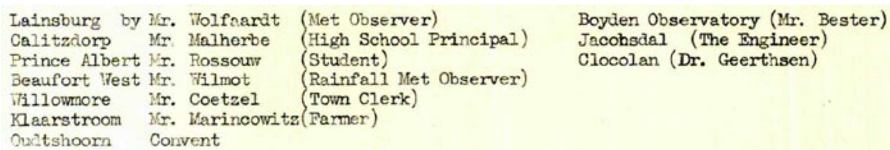
escopes were also modified with a mask over their apertures to do double-beam measurements (Fig. 17).

As mentioned already, right at the end of the campaign (July to September 1963), tests of the newly developed **Siedentoph Experiment**, (turbulent cell seeing measurements) were run at both Zeekoegat and Flathill. This used measurements of the rapid temperature fluctuations which accompany the turbulence in the atmosphere, which in turn, can be correlated with image quality. By mounting thermocouples and resistance thermometers at different heights on a tall mast, the dependence of turbulence on height was studied. These experiments played an important role in the decisions taken later with respect to the levels at which the telescopes in South America were to be mounted.

More than just astronomers

Although the bulk of the work was done by astronomers, non-astronomers also played a part. Ample use was made of locals to help gather meteorological data. Fig. 18 gives an idea of how diverse this group actually was. (ESO Seeing Expedition, 1956)

The final comprehensive programme of site testing required some extra staff. The type of person required was someone prepared to spend extended periods at isolated places, living under primitive conditions, capable of elementary cooking, handy in technical matters, and possessing the gifts for improvisation and readiness to perform over extended periods of routine work. It was realised that this description fitted an ambitious boy-scout exactly. Recruitment was thus directed at a Dutch journal for boy-scout leaders, with very rewarding results. Two such successful applicants later became permanent ESO employees (Fig. 19).



Lainsburg	by Mr. Wolfaardt	(Met Observer)	Boyden Observatory (Mr. Bester)
Calitzdorp	Mr. Malherbe	(High School Principal)	Jacobsdal (The Engineer)
Prince Albert	Mr. Rossouw	(Student)	Clocolan (Dr. Geerthsen)
Beaufort West	Mr. Wilmot	(Rainfall Met Observer)	
Willowmore	Mr. Coetzel	(Town Clerk)	
Klaarstroom	Mr. Marincowitz	(Farmer)	
Oudtshoorn	Convent		

Fig. 18: This list from the minutes of a meeting held at the Cape Observatory in November 1956, shows how diverse the group of meteorological observers were. Credit: SAAO Archives

Fig. 19: Jan Doornenbal (left) and Bert Bosker went from Boy Scout leaders in the Netherlands, to ESO site testers in South Africa to ESO employees in South America. Credit ESO, D Beintema

These Europeans visiting and working in South Africa returned with lasting impressions of the beauty of the country and the hospitability of its people. As can be expected, life in South Africa had its lighter moments as well. A local trend started to emerge where the standard of living at these remote outstations got measured by the number of donkeys at each one! So much so that an "edict" had to be issued from Europe to limit the proliferation of donkeys (Fig. 20)! (Fehrenbach 1981)

South Africa vs. South America

News of the promising results of American tests in the Andes reached European astronomers, first bit-by-bit, then more impressively. The reaction in the May 1959 meeting still read: "This will have very little influence on the development of ESO." But interest started growing soon after and by June 1961 it was planned to send a Danjon telescope and observer to Chile. By November 1961 it was decided to participate in the American site testing campaign and that one or more ESO committee member would visit South America.

It soon became clear that conditions in Chile were superior to South Africa in a number of respects. Statistics for cloudiness showed that the number of clear nights on Cerro Tololo was about 40% higher than in the Zeekoegat – Beaufort West area. The temperature fluctuations during a night in Chile were generally very small, compared to South African sites – such lower temperature fluctuations normally resulted in better seeing. No satisfactory direct comparison of the seeing between South Africa and Chile was possible because of the different methods employed in measur-

Fig. 20: The entrance gate to the Zeekoegat station in 1962, showing some of the infamous donkeys in the foreground and the observatory buildings in the background. Credit ESO, D Beintema

ing it. It was however possible to show that the seeing conditions were superior in Chile. Extinction results between the two countries were very comparable. The average wind velocity on Tololo was higher that at Zeekoegat, but lower than on Rockdale Mountain (Fehrenbach et al, 1963).

The decision to favour South America for hosting ESO came rather suddenly, taken during the committee meeting of 15 November 1963. To add insult to injury, the final South African site testing report was only published in 1967!

Bewilderment and Consent

Quoting from Blaauw (1989-2): "The rather sudden switch from South Africa to Chile did not pass without bewilderment to the young astronomers and their collaborators still at work in South Africa. Had years of effort been wasted? Some disappointment was undeniable. Disappointment would soon make room to the conviction that the decision had been right."

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