Table 1. *Orbital Parameters of Comet P/Grigg-Skjellerup*

Epoch	1992/07/10.60226 ET
Perihelion Time	1992/07/22.13729 ET
Perihelion Distance	0.9946892 AU
Eccentricity	0.6643366
Argument of Perihelion	359.27567 deg
Longitude of Ascending Node	212.63159 deg
Inclination	21.10411 deg
Non-gravitational Parameter A1	+0.0153 E-8 AU/day^2
Non-gravitational Parameter A2	−0.0012 E-8 AU/day^2

to communicate the astrometric positions of the comet to ESOC within a few hours to two days after observations in order to allow an immediate update of the cometary orbit for the fly-by planning of GEM. All positions of the comet reaching ESOC before July 8, 1992, will be considered in the planning for the GIOTTO encounter. However, of highest priority for the fly-by targeting are position measurements of P/Grigg-Skjellerup obtained within two months before the encounter. During this period the comet will be best observable from the southern hemisphere though it might be a difficult task since the comet will be faint and close to the horizon. Observations are being planned at ESO La Silla, in collaboration with R. West, who also observed Halley in 1986. For the improvement of the orbit determination accuracy so far unpublished position measurements of the comet obtained during previous apparitions (in particular in 1987, 1982, 1977) are very welcome at ESOC.

Astronomers who are interested to contribute to the P/Grigg-Skjellerup astrometry campaign for the GIOTTO fly-by may contact for further information:

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The Vaca Muerta Mesosiderite

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The lonely Atacama desert is a perfect place to study distant celestial bodies in the space around us. The following story shows how this may be done, not only through powerful astronomical telescopes at isolated mountain-top observatories, but also down on the barren desert plain in a much more direct way.

We have just completed a detailed study of a gigantic, but little known meteoritic impact in a remote region of the Atacama Desert. Over a period of four years we carefully searched a large area in the middle of nowhere and collected seventy-seven specimens of the Vaca Muerta ("Dead Cow") meteorite with a total mass of more than 3400 kg. This meteorite is of the rare stony-iron type (mesosiderite) and our finds have more than tripled the available material of this type which is of great importance for the study of the early history of our solar system. We did this work in our spare time and should like to express our great appreciation for the excellent collaboration with meteorite-oriented scientists in various countries as well as with the Chilean authorities.

Two of us are used to observe remote objects in space, but it was really great fun for once to do down-to-Earth astronomy and to work with our geologist-colleagues!

The Fall of the Vaca Muerta Meteorite

In addition to the large planets and their moons, there are many smaller solid bodies which move in elliptical orbits in the solar system. They come in all sizes, from *minor planets* with diameters above a few hundred metres, to metre-sized *meteoroids* (boulders) and down to microscopic *dust*.

From time to time, a small dust grain from interplanetary space enters the Earth's atmosphere with a very high velocity, often of the order of 10 km/sec or more. It is immediately heated by the friction with the air and begins to glow; this is what we call a *meteor* (a "shooting star"). Such events are very frequent and can be seen on every cloudfree night. More rarely a larger object, even a small boulder, may enter and will then be seen as a bright *bolide*. It leaves a luminous trail across the sky which can sometimes be seen in full daylight. If the boulder is big enough, a part of it will survive the descent through the atmosphere and will hit the ground, where it may be found as a *meteorite*.

About 3500 years ago, a large meteorite with a mass of several tons and measuring at least one metre across fell from the sky over the central part of the Atacama Desert in northern Chile. During its rapid passage through the Earth's atmosphere the big stone disintegrated into numerous smaller pieces which impacted in the desert sand over an area of some 20 km^2. Here they remained in well-preserved condition, due to the extremely dry conditions in the desert.

The fall-zone lies in a very remote part of the desert and most of the meteorite

Figure 1: *This photo shows Harri Lindgren at a miner's depot of fragments from the Vaca Muerta ("Dead Cow") meteorite, just after discovery during a field trip in the fall area.*

This stony-iron meteorite fell about 3500 years ago in the Chilean Atacama desert, at a site about 60 km inland from the coastal city of Taltal and about 100 km from Paranal, the site of ESO's VLT Observatory. The meteorite broke into many smaller fragments, which are spread over a 20 km² area.

Some of these pieces were first discovered by miners in the early 1860's, who thought that the heavy stones contained silver. They collected many of the larger fragments and worked on some of them in order to extract the valuable iron-nickel nodes inside.

The meteoritic stones in the foreground are darker than the other stones in this absolutely barren desert. Some of the miners' stone tools are seen in the background. The darker flakes on the sand indicate that the fragments have been worked on, more than one hundred years ago.

However, most of the seventy-seven fragments of the Vaca Muerta meteorite which were recovered were untouched by the miners.

fragments escaped notice until recently. However, some of them were collected already in the 1860's, when prospectors first travelled through this inhospitable region in search of precious minerals. When they found some heavy masses which became shiny when polished, they thought they had hit upon a silver-mine. They collected some stones and brought an unknown number to the mining town of Copiapo, perhaps more than 1000 kg altogether.

Most of this material was probably discarded, but some stones (in total about 45 kg) found their way into mineral collections and were recognized as meteoritic. A few years later this meteorite fall was given the name "Vaca Muerta" (the Dead Cow) after a nearby dry riverbed (Quebrada Vaca Muerta), but soon after, the exact location was completely forgotten.

For more than 100 years, nobody knew where the Vaca Muerta meteorite had fallen. However, in 1985 the site was rediscovered by Edmundo Martinez, following a lengthy study of the old accounts. At that time Martinez was a student of geology at Universidad del Norte, Antofagasta; he still lives there, while he runs a travel agency in San Pedro de Atacama, a small town in the middle of the Atacama desert.

Searching for the Pieces

In addition to a few fragments which had been collected and worked on by miners in the last century (in order to extract the valuable iron-nickel clumps within them), Martinez found one big body which had not been molested. His brother spoke of this discovery to one of us (CdB), and soon thereafter we decided to embark upon a scientific study of the area.

This involved a rather painstaking on-foot search of the fall area, which we found to measure about 11×2 km. The distribution of the recovered pieces indicates that the meteorite entered from East-South-East, i.e. it flew over the high Andes mountains before the impact. One of the largest fragments hit the ground with such a force that a 10-metre crater was excavated to a central depth of almost 2 metres.

In total, we located 77 specimens during ten expeditions to the area between February 1987 and January 1991. Twenty of these pieces had already been displaced and partly worked on by the miners (Fig. 1); this was also indicated by some artifacts from last century which were found nearby, including mining tools, cooking utensils, cans, beer and cognac capsules, corks, horse-shoe nails, parts of boot soles and a coin from 1871. But 57 specimens, ranging from a few grammes to one piece weighing no less than 309 kg, were found in "virgin" condition, i.e. undisturbed since the fall, except for some erosion. Such pieces are particularly valuable for meteoritic studies.

We have now prepared a very detailed, scientific account of this work with the title "Vaca Muerta Mesosiderite Strewnfield" which will soon appear in the international journal *Meteoritics* of the Meteoritical Society, the world's foremost authority in this scientific field.

The Scientific Study Begins

All meteoritic material has now been recovered and is safely kept in Chilean collections, in particular at the Universidad de La Serena and also at the Museo Nacional de Historia Natural, Santiago de Chile. The combined mass exceeds 3400 kg and the meteorite is therefore by far the largest known in its class; this type of meteorite is much more rare than the common stony and iron meteorites.

Detailed laboratory analysis of the Vaca Muerta meteorite has begun and it is slowly unveiling its dramatic story. Its age has been dated by radiochemical methods and mineralogical studies are made of its composition and internal

Figure 2: *Twelve small masses of the Vaca Muerta Meteorite with a total mass of 9.7 kg, as they were found in the Atacama desert. From left to right: Holger Pedersen, Canut de Bon (son), Canut de Bon (father) and Harri Lindgren.*

structure. The time of the fall was determined as 3500 ± 1300 years before present by means of Carbon-14 dating by A.J.T. Jull of the University of Arizona, Tucson, U.S.A. This technique is based on the fact that while the meteorite is still in space, it is continuously bombarded by cosmic rays, leading to a particular internal proportion of Carbon-12 and -14 atoms. As soon as it passes through the Earth's atmosphere, it is shielded from cosmic rays and the proportion begins to change as the radioactive Carbon-14 atoms decay. A measurement of this proportion will therefore indicate the time since the fall.

Some of the minor planets, along with the comets, are thought to consist of material that dates back to the very beginning of the solar system. The minor planet from which the Vaca Muerta meteorite derives is about 4500 million years old and therefore nearly as old as the solar system itself.

The early life of this minor planet was obviously very violent. At some time a partially molten, volcanically active body moving at high speed through the solar system collided catastrophically with a metallic-core minor planet. When the finely intertwined materials cooled and solidified, they formed a cosmic breccia (mixture of minerals) which was half stony and half metallic. Later, after an unknown period of time, this minor planet split into a swarm of smaller fragments, some of which now fall to the Earth at rare moments. One of them was the Vaca Muerta meteorite.

This particular kind of stony-iron meteorite is known from about 30 other locations only. The amount recovered at Vaca Muerta has tripled the material available to laboratory study. When fully analysed, the seventy-seven "dead cows" from Atacama will undoubtedly provide us with much new insight into the enigmatic history of the early solar system.

New ESO Publications

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ESO Technical Report No. 15: "A Study of the Potential of Heterodyned Holographic Spectrometry for Application in Astronomy" (Eds. N. Douglas, F. Maaswinkel, H. Butcher and S. Frandsen).

GPO Observations of a Geostationary TV-Satellite Quartet

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1. Introduction

During an astrometry campaign on asteroids a test was performed to observe geostationary satellites with the GPO 40-cm astrograph at ESO La Silla/Chile. In several nights from April 10 to 22, 1991, spacecraft located at geostationary longitude 19 deg West about 35800 km above the equator were photographed with the GPO. At this longitude in total four telecommunication satellites are operated by three different control centres, i.e. TDF-1 and TDF-2 by CNES Toulouse, OLYMPUS by Telespazio Fucino under contract of ESA and TV-SAT-2 by GSOC/DLR Oberpfaffenhofen.

In order to guarantee the contact with the fixed mounted user antennas on ground, the individual spacecraft have to be kept in control boxes of certain latitude and longitude intervals. The respective control boxes are in inclination below 0.1 deg for all four satellites, in longitude within 18.7 to 18.9 deg West for both TDF satellites, within 18.9 to 19.1 deg West for OLYMPUS and within 19.1 to 19.3 deg West for TV-SAT-2. A violation of these so-called deadbands by one of the satellites may not only cause problems for the users on Earth because of fading signal strength, but may also be a risk for the spacecraft themselves in particular if the longitude window of a neighbouring satellite is entered and a collision of both satellites may occur. Since perturbations from the Earth, the Moon and the Sun cause a geostationary satellite to drift away from its nominal position, the control centres have to correct the orbit regularly both in inclination and in longitude by so-called "station-keeping manoeuvres".

2. The GPO Observations

The geostationary longitude 19 deg West over the Earth equator compares to the telescope coordinates of +4.6 deg in declination and hour angle 3h 52.8 min East for the La Silla observatory. During the about 30-minute time interval of dark-room work per night (in order to change plates for the asteroid programme) old ORWO ZU21 plates found in the refrigerator of the telescope building were exposed with the tele-