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GRAVITY MEASUREMENTS IN SUPPORT OF LONG-BASELINE GEODESY

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This grant is to provide continued support for gathering and preliminary analysis of gravity data that are believed to be relevant to unknown questions of earthquake premonitory crustal processes, and that best compliment the information provided by the NASA geodetic techniques. Gravity data, in concert with the NASA long-baseline geodetic measurements, will be a key factor in interpretation of crustal distortion episodes and their relationship to earthquake premonitor models.

The NASA Grant NAG5-21 was for the one-year period of March 1980 - February 1981. A one-year no-cost extension was applied for in order to stretch the funding and keep the project alive until alternative funding could be obtained after a NASA decision to cease support of gravity operations. This extension necessarily required that the observation schedule could not be as frequent during the 1981 time period and, unfortunately, some stations could not be occupied at all during this time. However, the Southern California Gravity Network as shown in Figure 1, is now under support of the USGS and operations are back to normal. NASA/JPL has supported the first seven years of the gravity network operations and the resulting baseline of gravity values at over thirty stations represents one of the best and most continuous sets of geophysical data in Southern California.

In early 1981, absolute gravitational acceleration measurements were made with M. Zumberge at four key stations within the network using the instrument developed at the University of Colorado Joint Institute for Laboratory Astrophysics (Zumberge and Faller, 1980). Measurement of absolute gravity now allows the network to be tied to a fixed gravitational frame of reference instead of a floating frame as was the case during the first eight years of network observations. Now, any observed change in gravity can be tied to a specific locale by means of a repeat observation of the absolute stations. The four-station network of absolute gravity stations can also be used to provide absolute calibration to gravity meters used in the network. One of the absolute gravity stations OVROA is now tied to gravity networks in the Mammoth Lakes-Mono Lake, California region in investigations of the USGS (R. Jachens, personal communication) and the DOE (Sandia Laboratories) of the volcanic/geothermal activity of the region.

The absolute stations and their gravitational acceleration values in April 1982 are as follows:

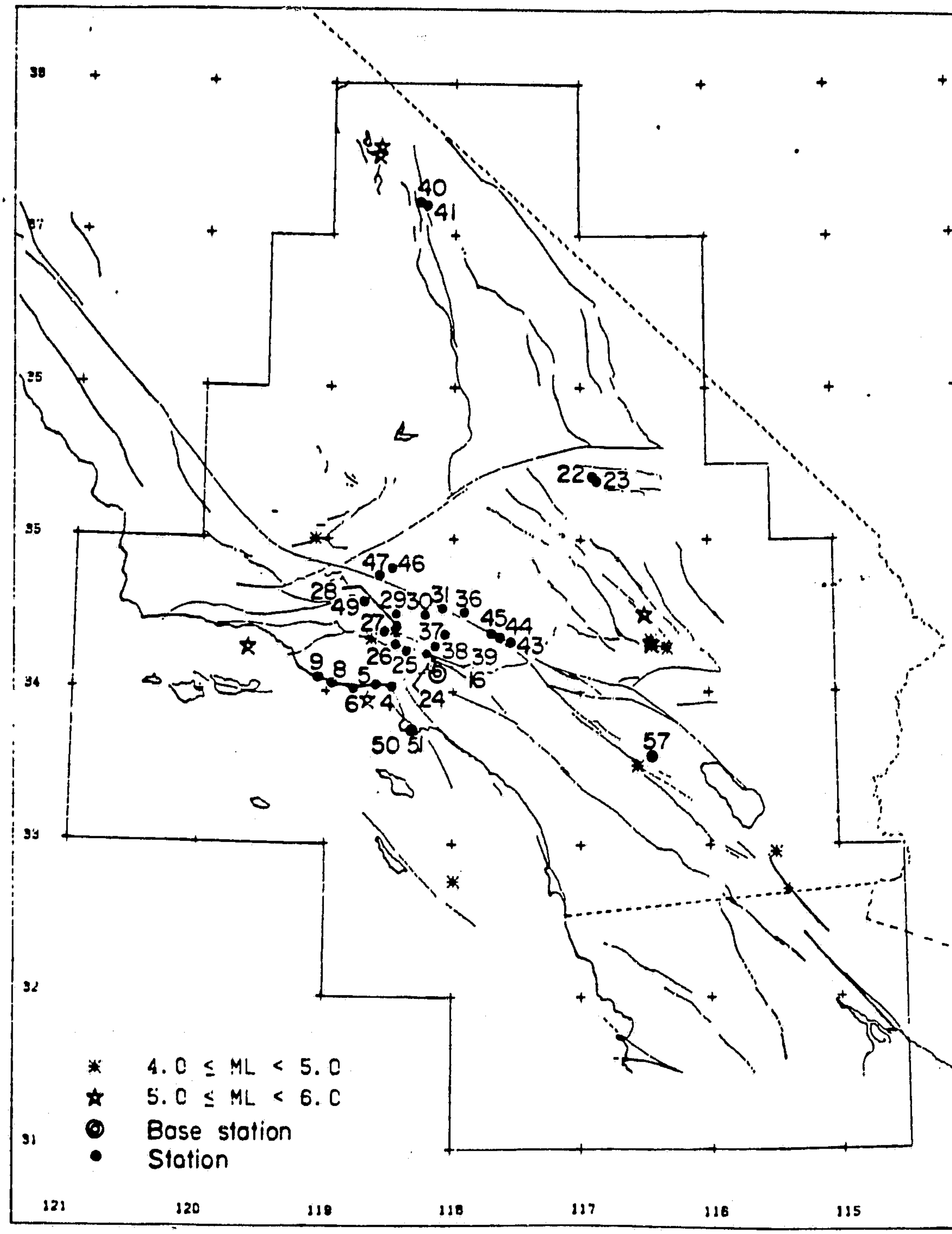

Figure 1. Locations of stations of the Southern California gravity network.

Station	No.	cm/sec^2
PAS	base station	979.560445
GSC	23	979.444215
PINON	57	979.284080
OVROA	40	979.444404

The station number corresponds to those in the map of Figure 1. Figure 2 shows a sample single determination of absolute gravity at PAS on April 1, 1982. Typically, eight of these determinations are made within one day and, after tide and laser calibration corrections are made, are averaged to give the final determination of absolute gravitational acceleration. Stations PAS, GSC, and PINON are on piers on concrete that is in direct contact with crystalline rock. The OVROA station is tied directly with LaCoste-Romberg gravimeters to a nearby benchmark that is on crystalline rock. All four stations are in a sheltered environment with electric power available. Effects of groundwater and other environmental factors are therefore negligable. PAS is the single base station used for the gravity network observations.

Appendix I shows gravity data from the network. Station numbers can be located from the map of Figure 1. A five-point weighted moving average has been used to smooth the data and a range of plus and minus two standard errors of the mean is plotted with the individual readings. Earlier analysis has shown that movement of the smoothed average out of this range is a reliable indication of a real gravity change at the station.

Most of the gravity changes seen in the data of Appendix I are small and close to the resolution of the technique about 30 microgals. The 30-40 microgal changes seen in the GOLDST (#22) data have been correlated to leveling changes (Whitcomb; 1980) and independent gravity data (Whitcomb, et al., 1980) and have been shown to be real. These changes take place over periods of as short as a few months. More recent changes of the GOLDST data relative to

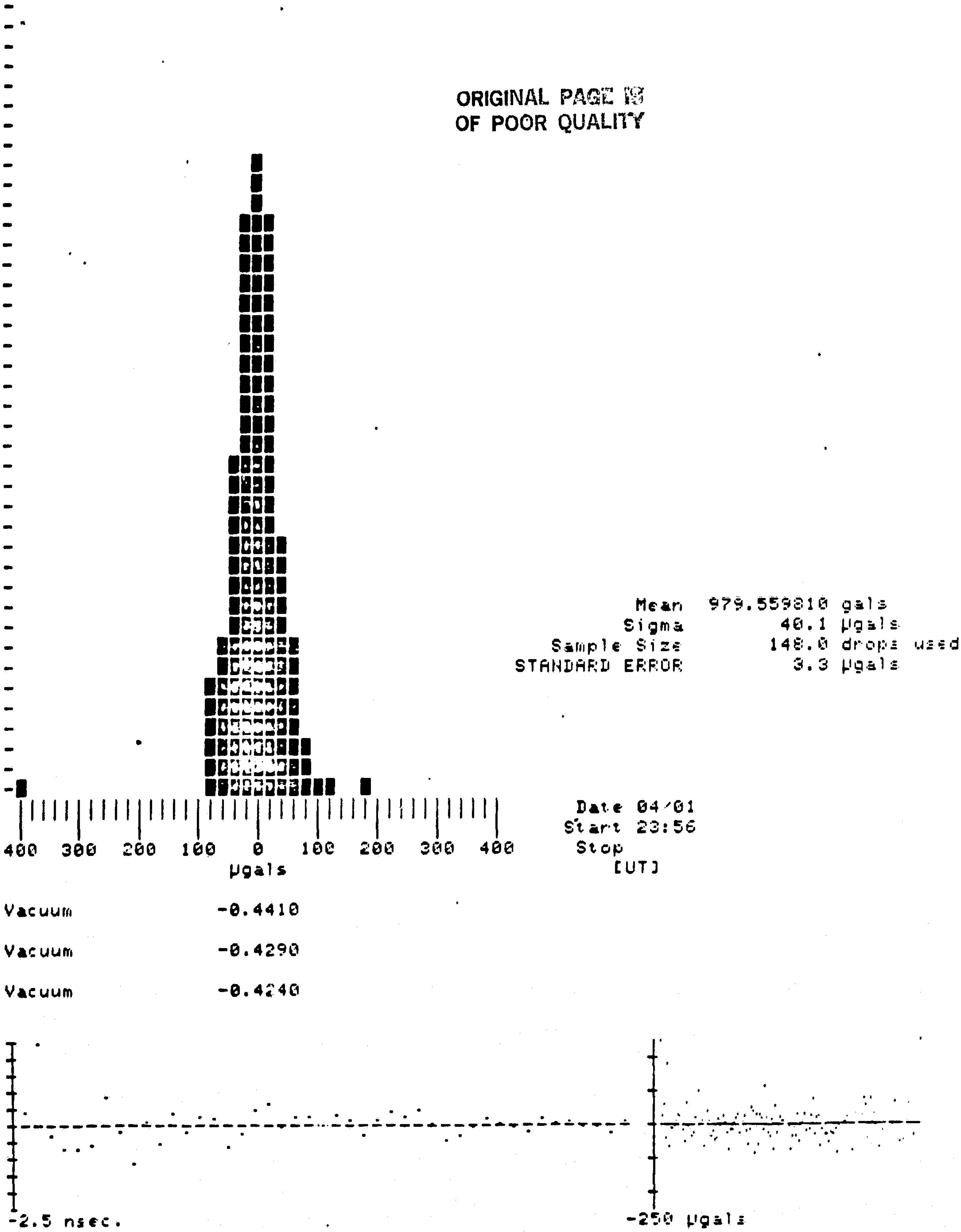

Figure 2. A histogram of a single determination of absolute gravity at the base station AAS. Eight determinations within one day are averaged to give the absolute gravity value. Scatter of the determinations gives a standard deviation of about 10 micrograls.

Pasadena show an increase in mid-1979, a decrease by early 1980, and an immediate increase again by 1981 continuing high until late 1982.

Stations over high-porosity sediment basins can be affected by varying groundwater levels. Stations significantly affected are (Whitcomb et al., 1980):

NEWHALL (#27)
MINT (#28)
BLOSSOM (#36)
ANTV MT. (#46)
ANTV 138 (#47)

These stations are kept in the network to maintain coverage in important regions and to monitor rainfall effects in the area.

It has been shown that stations on mountain terrain can be affected by an amplified attraction of snowpack/snowmelt (Whitcomb, et al., 1980). Stations significantly affected are:

TIESUMIT (#37)
TABLE MT. (#45)

The PALM1 station (#31) shows a monotonic increase of 30-40 microgals beginning in 1978. While this change may be tectonic as the station is situated within the San Andreas fault rupture zone, it is more likely that the gravity increase is a result of a rising water table. Figure 3 shows water data (solid points) from a nearby well converted to predicted gravity change assuming a 13% porosity, and plotted with the PALM1 gravity data. This porosity was shown to be the best fit to gravity data at other well-control sites in the network (Whitcomb, et al., 1980). The only deviation of the predicted gravity from the moving four-standard-error range occurs in 1981, a time of sparse data when lack of support reduced network occupations.

Within the network, only two stations have gravity changes that cannot be attributed to groundwater or other causes. They are at LUCAS (#38) and CIT2 (#5). LUCAS is a crystalline rock site in the middle of the Transverse Range San

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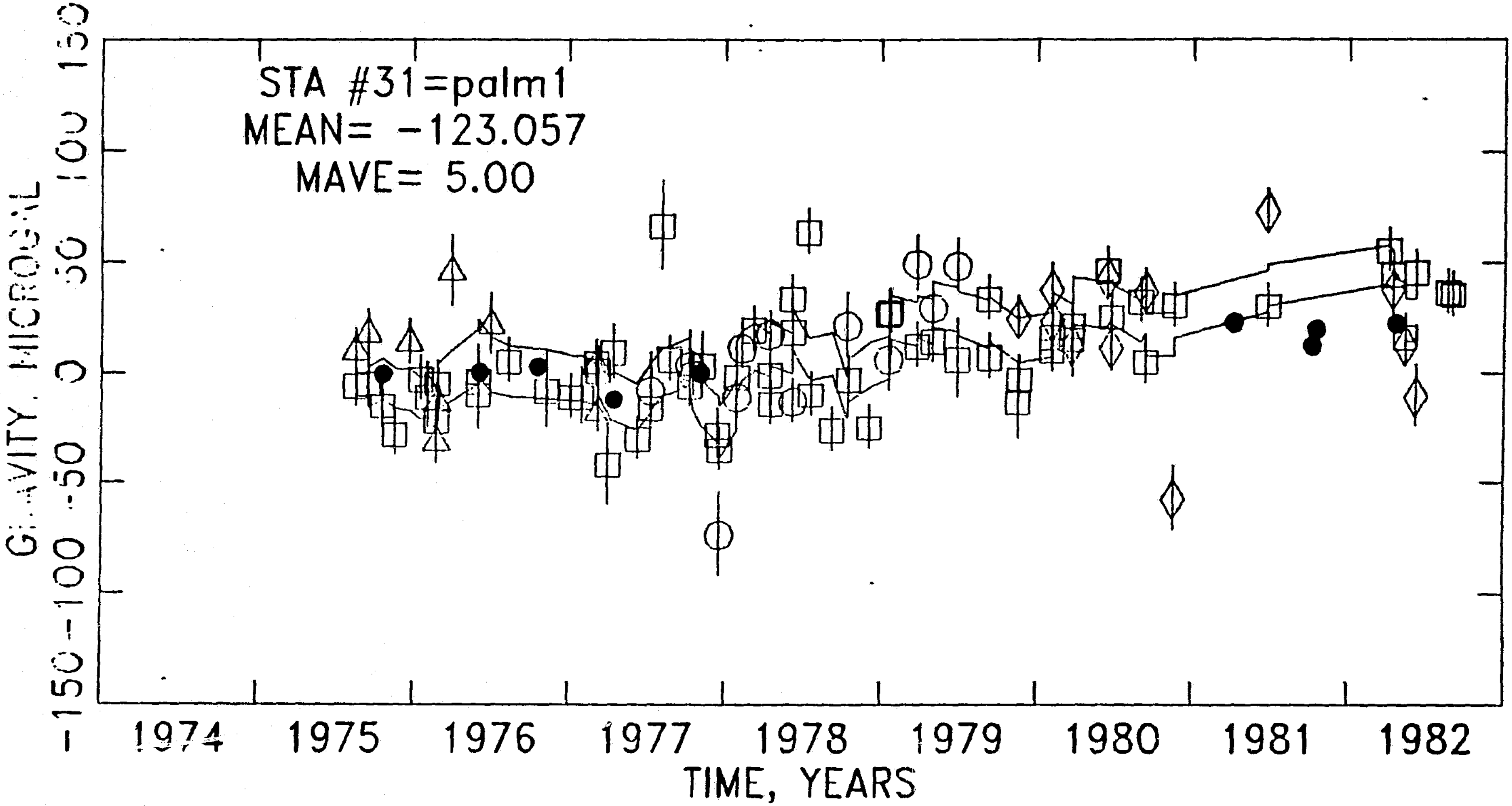

Figure 3. Predicted gravity changes (solid points) from well data (#8695A) near the PALM1 (#31) station plotted with PALM1 gravity values from Appendix I. A porosity of 13% is assumed for predicted values based on analyses from other parts of the network.

Gabriel mountains. LUCAS data in Appendix I is better viewed relative to a distant reference. Figure 4 shows LUCAS data relative to the GOLDST (#22) station which is in the northeastern Mojave. A decrease of about 40 microgals is seen from early 1979 to late 1982.

The CIT2 (#5) data shows a larger offset. The station is located on the Malibu coast (see Figure 1) on a bridge abutment 5.5 meters above sea level and about 100 meter north of the shore line. Figure 5 shows the CIT2 data plotted against the same distant reference as in Figure 4, that is GOLDST (#22). Unfortunately, lack of project support during 1981 has made a gap in the data so that details cannot be discerned in this period. However, data from resumed operations in 1982 show continued high or higher values 50-80 microgals above the average levels in the 1974-1978 period. Figure 6 shows data from neighboring stations CIT1, CIT4, and CIT5 which are observed on the same loop during the same day as CIT2 readings are made. No similar 1982 increase in gravity is seen at the nearby stations; CIT1 is about 13 km to the east of CIT2, CIT4 is 27 km to the west, and CIT5 is 35 km to the west (see Figure 1). CIT3 has been temporarily lost because a housing development has closed access to the bench mark.

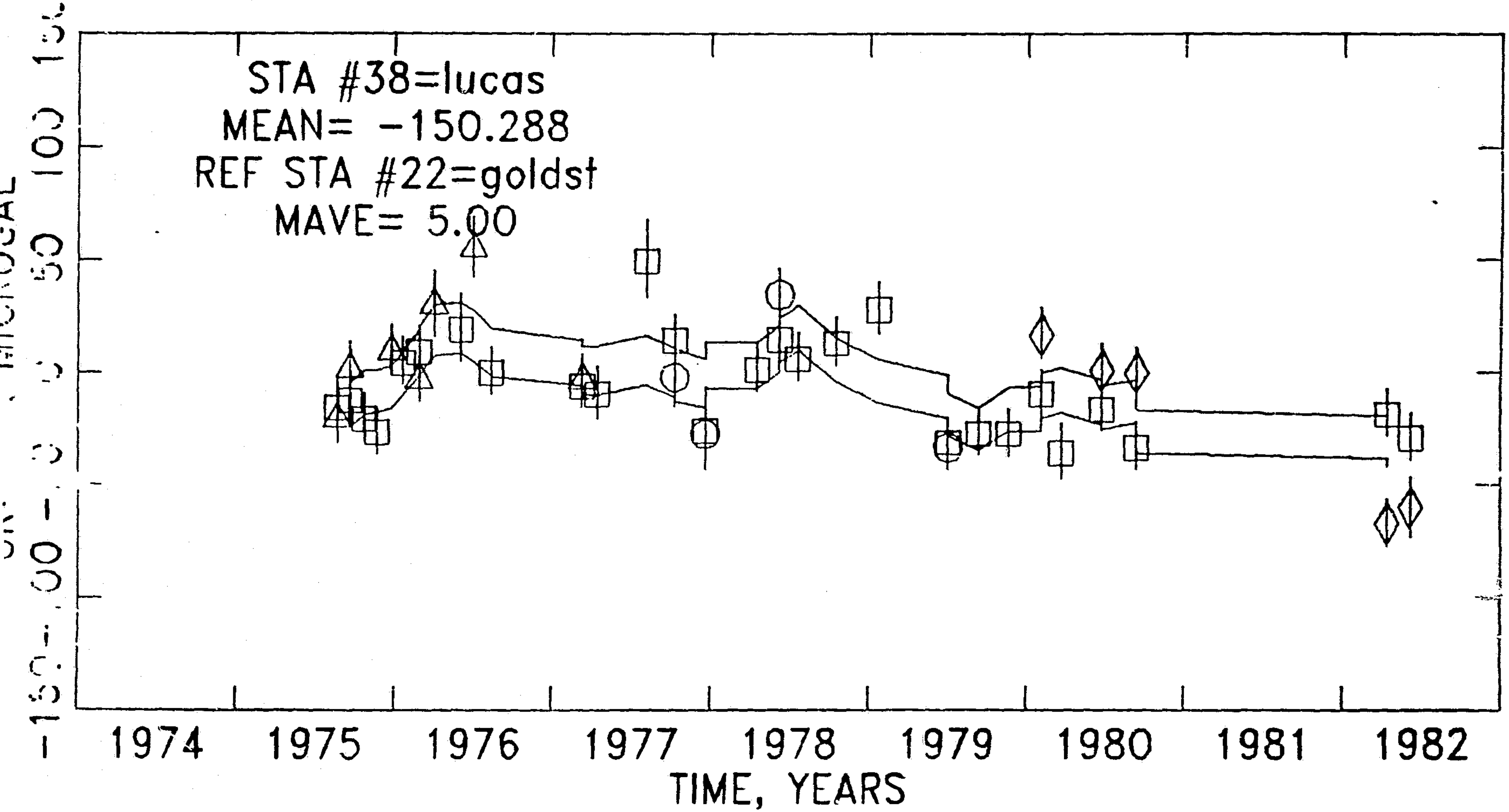

Figure 4. Gravity data from LUCAS (#38) relative to GOLDST (#22).

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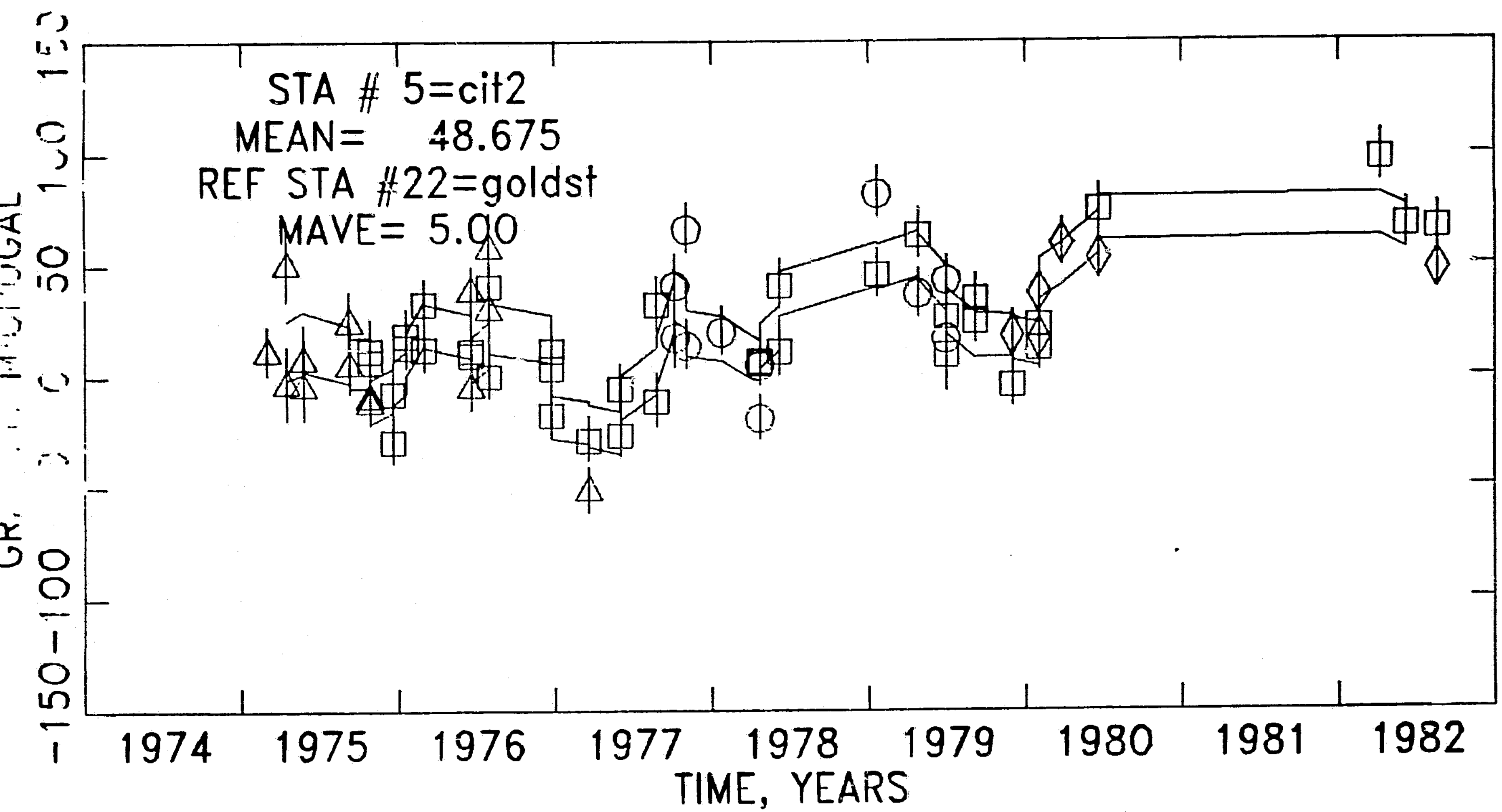

Figure 5. Gravity data from CIT2 (#5) relative to GOLDST (#22).

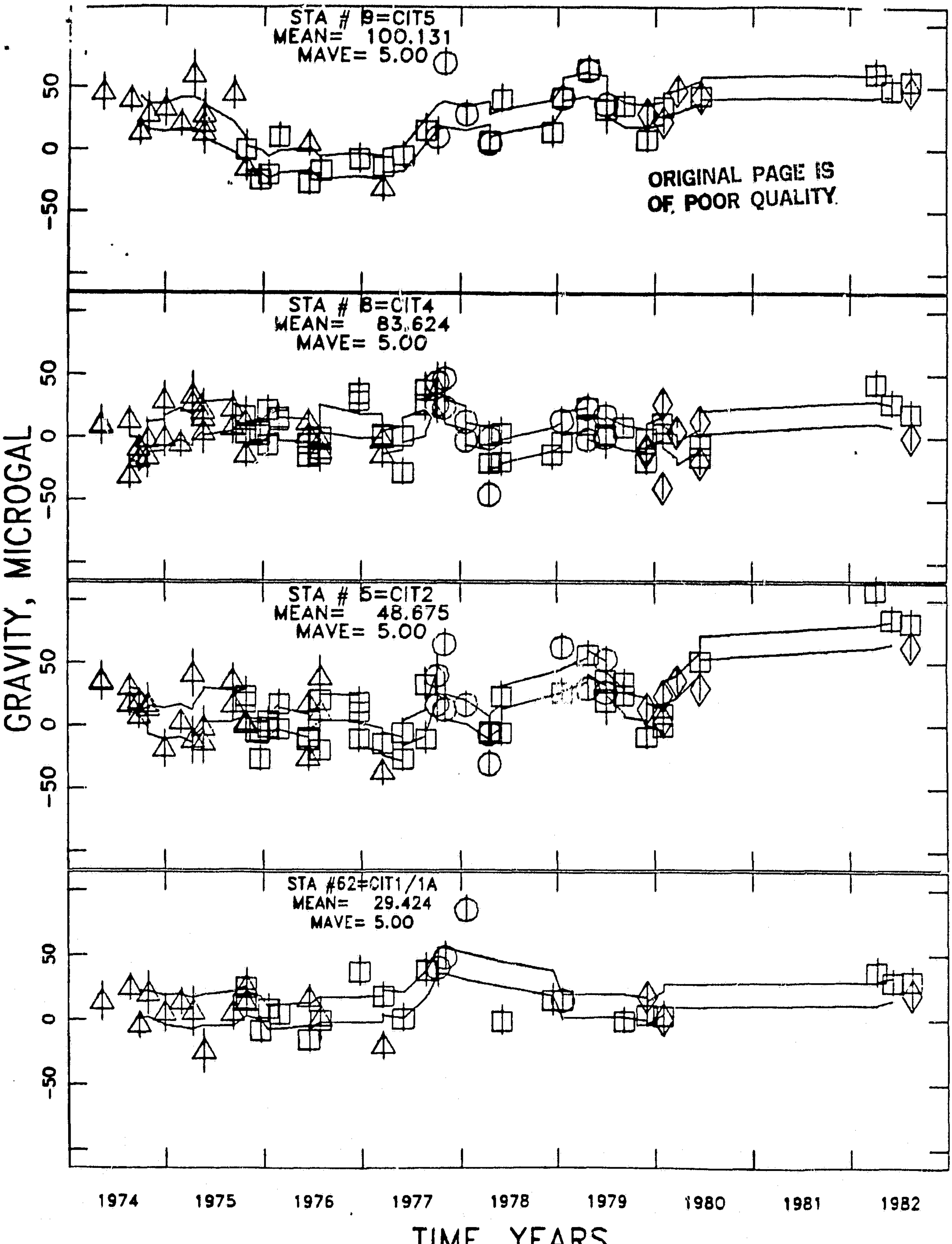

Figure 6. Gravity data from CIT1 (#62), CIT2 (#5), CIT4 (#8), and CIT5 (#9) relative to the Pasadena base station.

References

Whitcomb, J. H., Comparison of elevation changes as measured by orthometric, geometric, and gravimetric techniques in an area of the Transverse Ranges, California, *EOS, Trans. Am. Geophys. U.*, *61*, 1127, 1980 (abs.).

Whitcomb, J. H., W. D. Franzen, J. W. Givens, J. C. Pechmann, and L. S. Ruff, Time-dependent gravity in Southern California, *J. Geophys. Res.*, *85*, 4363-4373, 1980.

Zumberge, M. A., and J. E. Faller, Performance of a new, portable, absolute gravimeter, *EOS, Trans. Am. Geophys. U.*, *61*, 938, 1980 (abs.).

Appendix I

Gravity data from the network. Station locations are shown in Figure 1. All stations are relative to the base stations in Pasadena with a constant value, the "MEAN" in the figure titles, subtracted. The moving band is a four-standard-error of the mean interval calculated from a five-point weighted moving average of the data. Different symbols indicate different gravity meters in operation.

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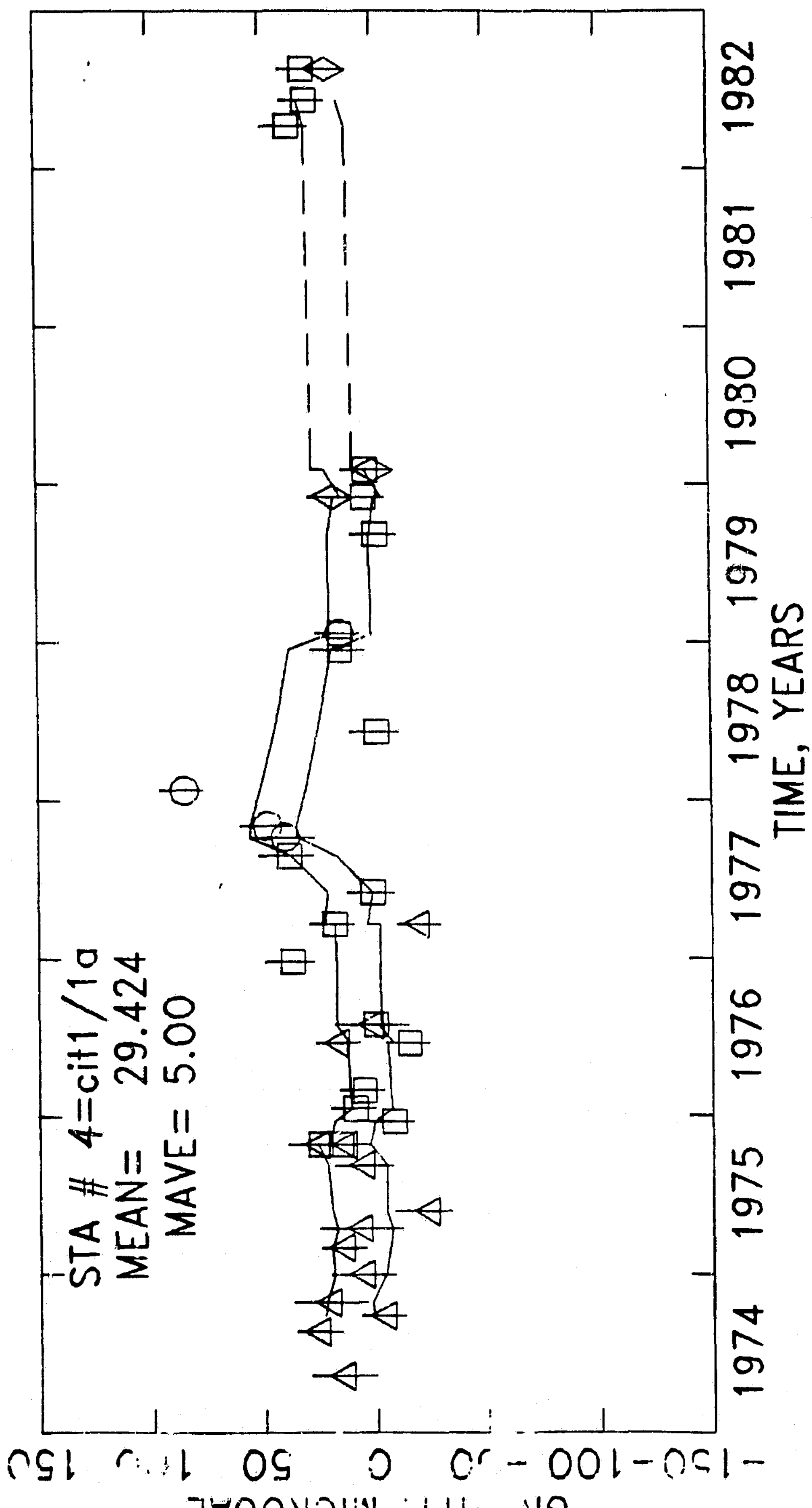

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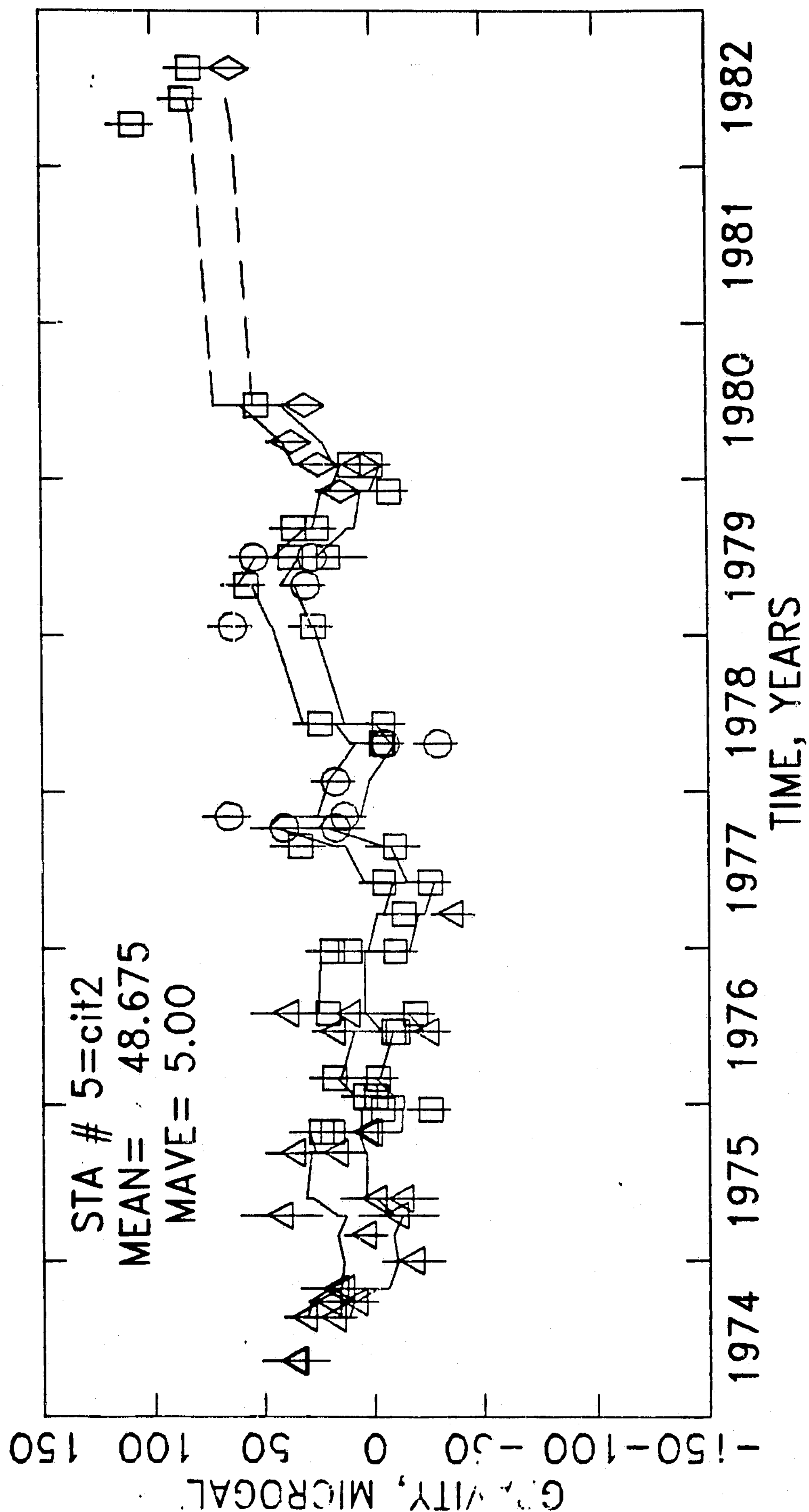

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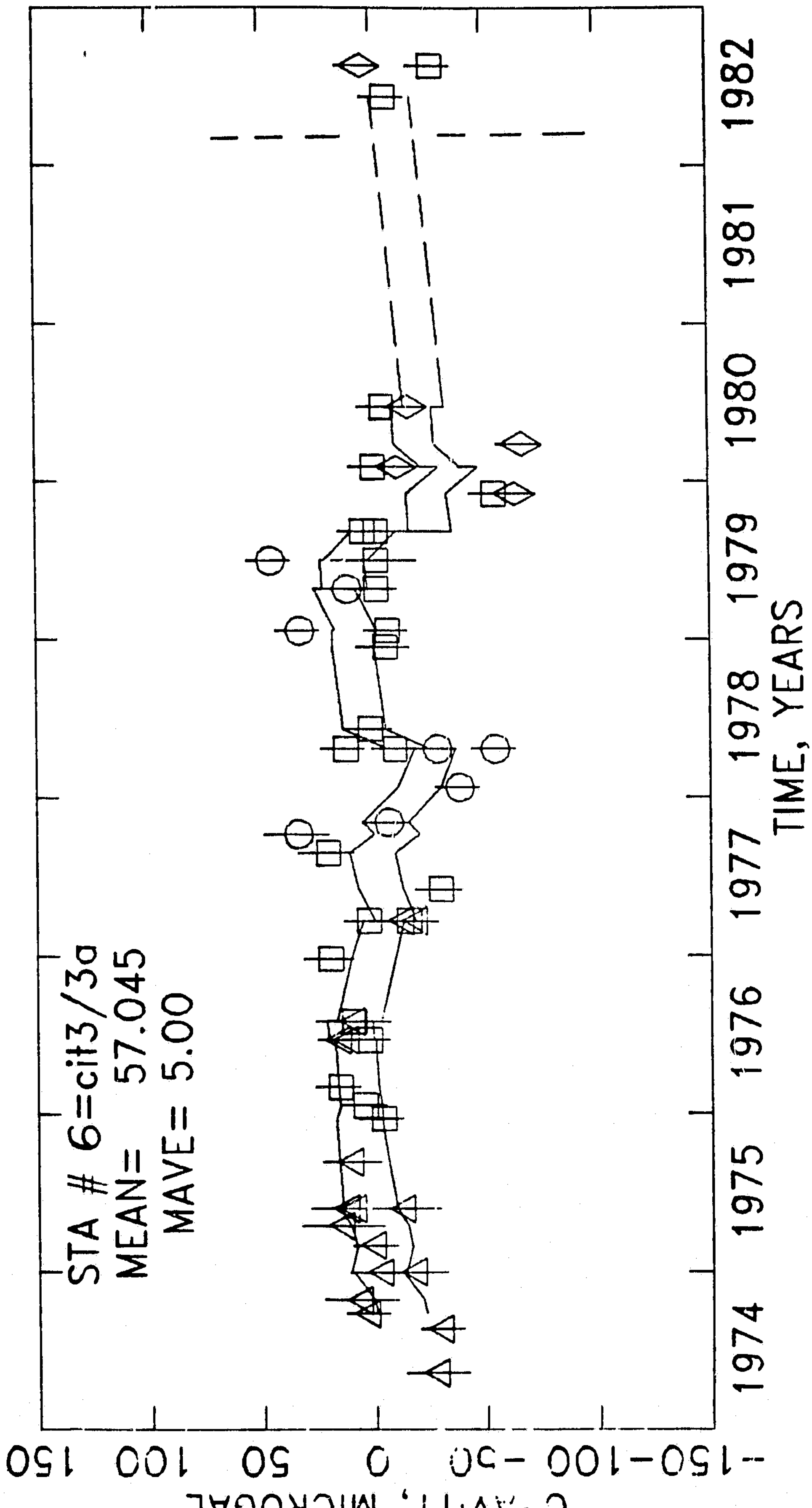

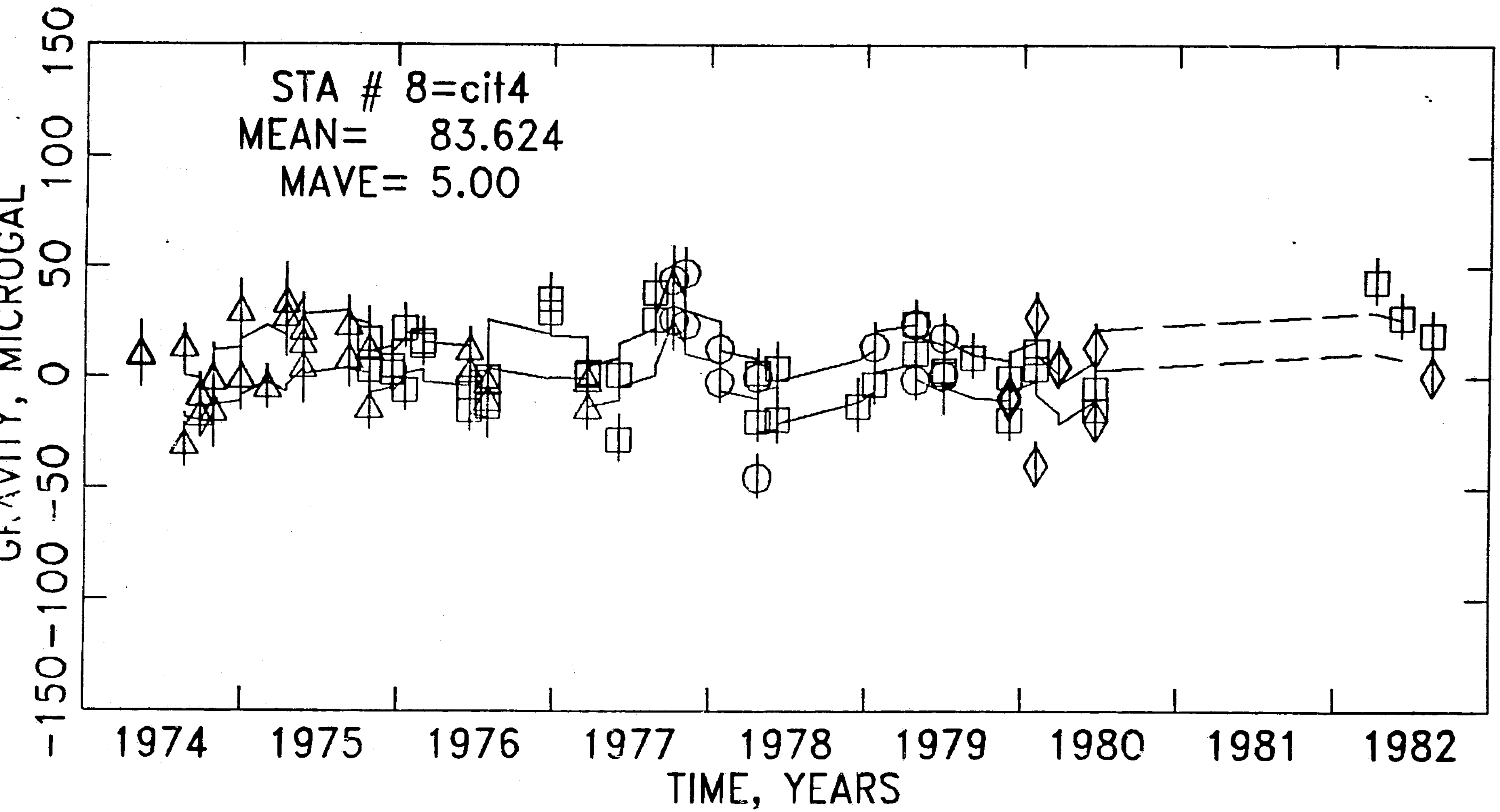
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-50
-100
-150
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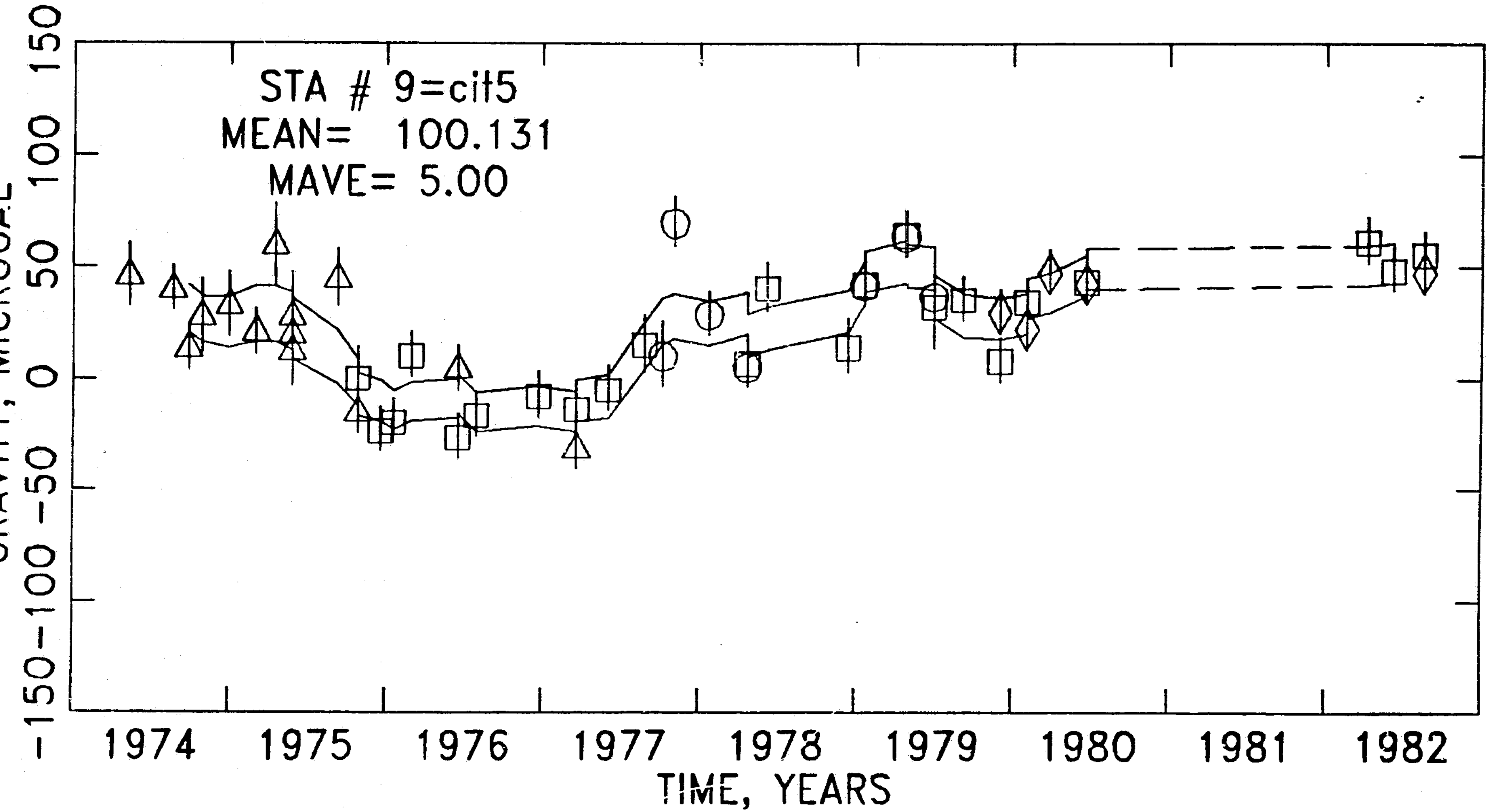
TIME, YEARS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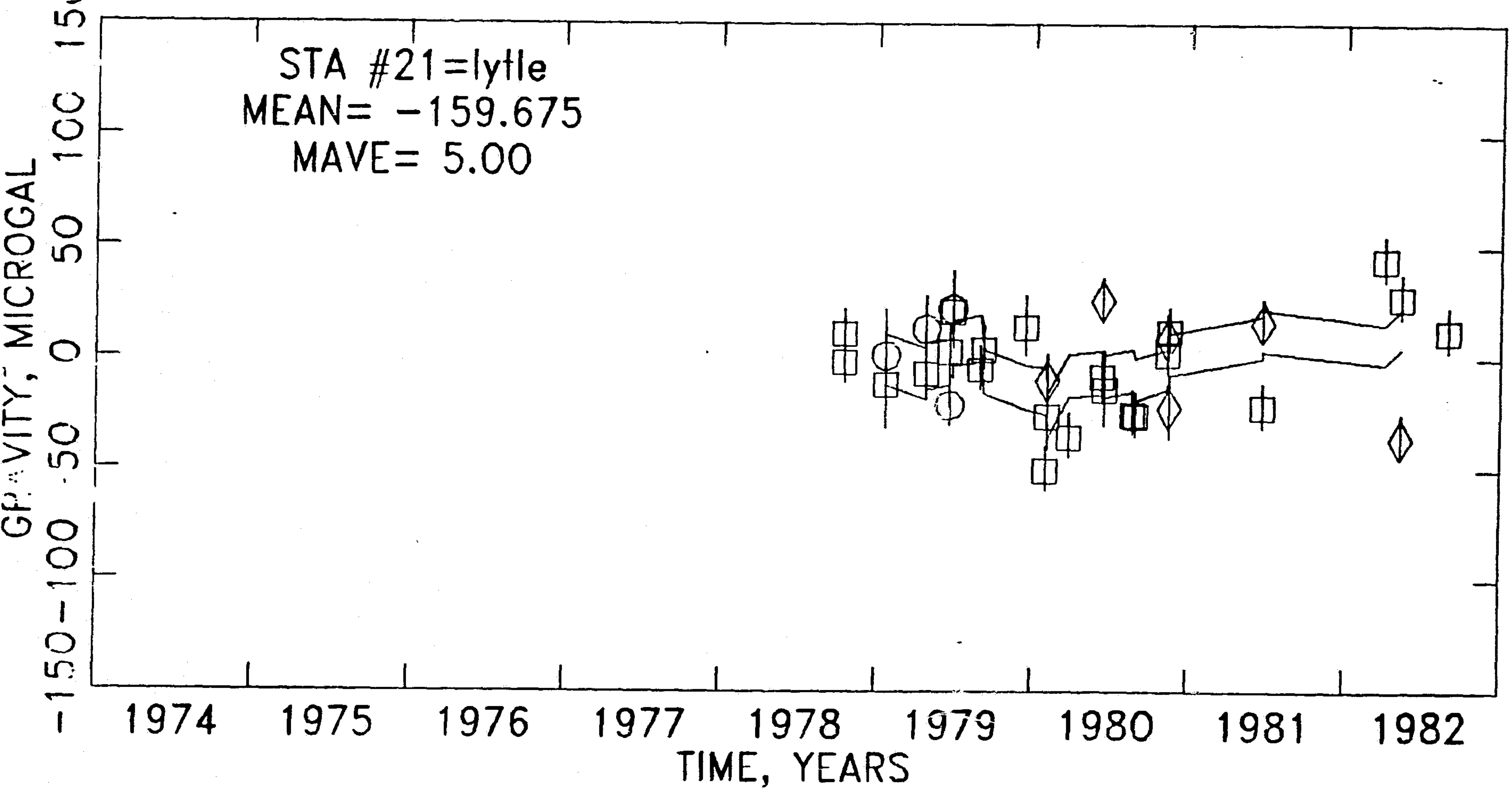
TIME, YEARS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TIME, YEARS

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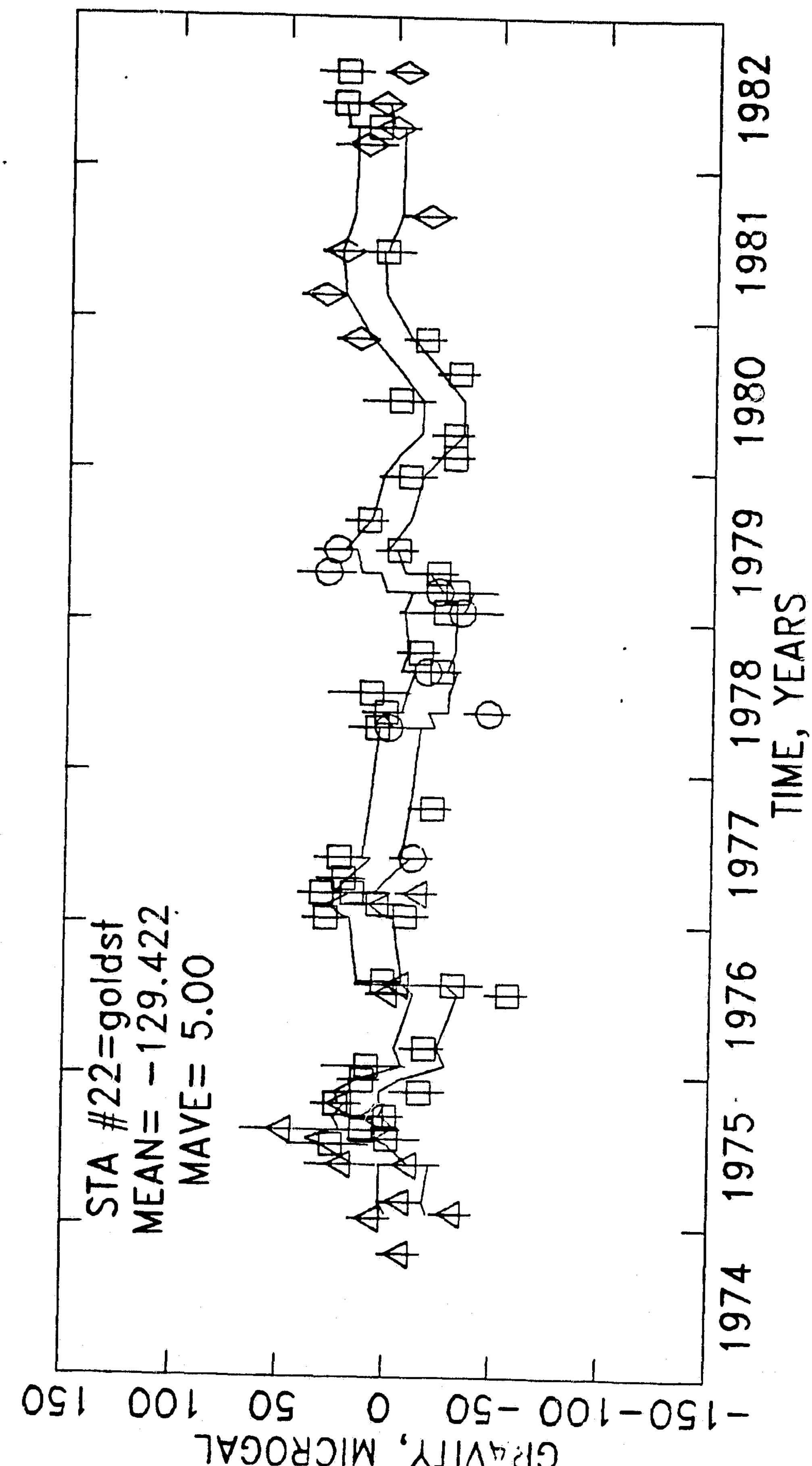

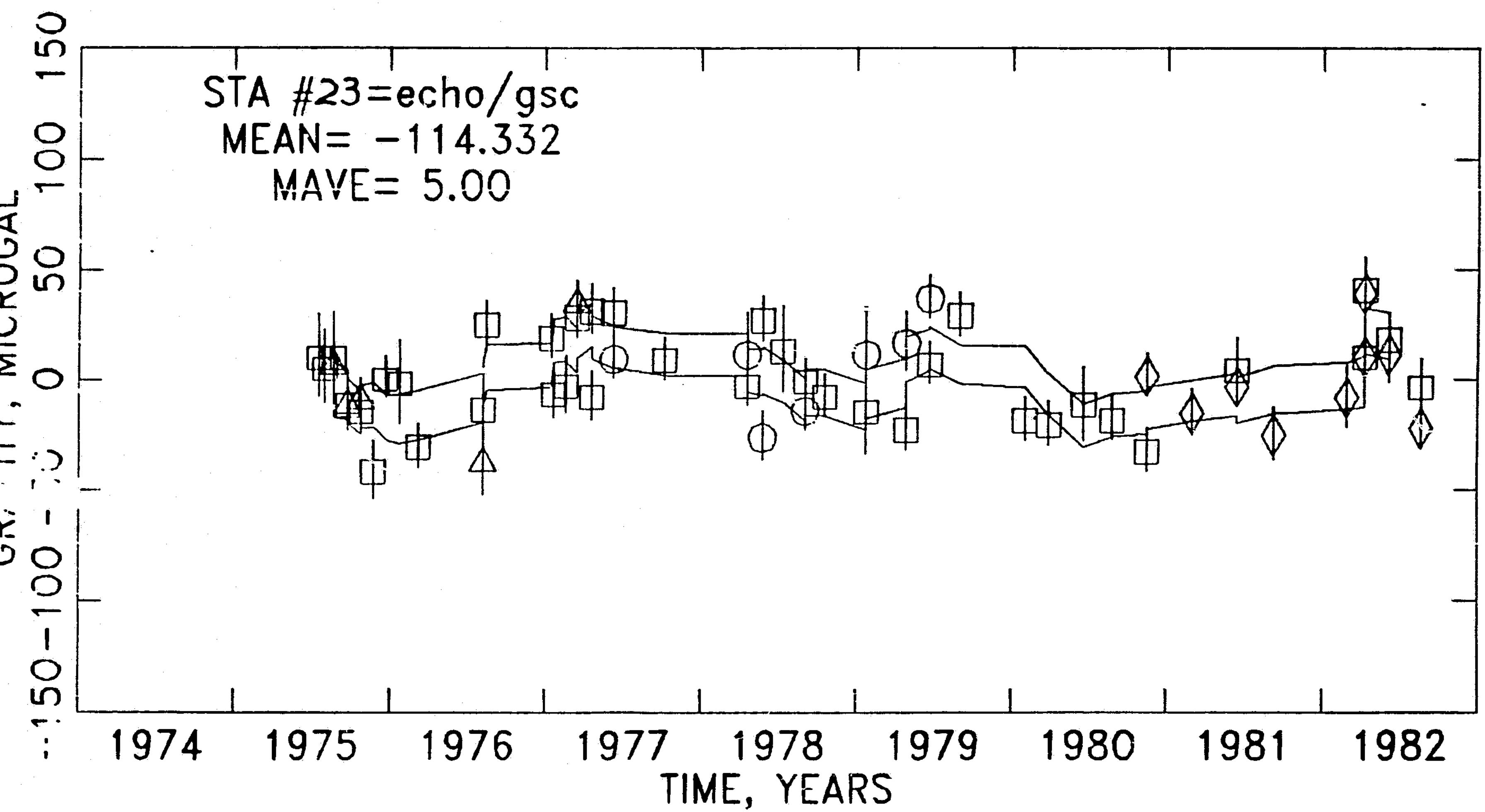
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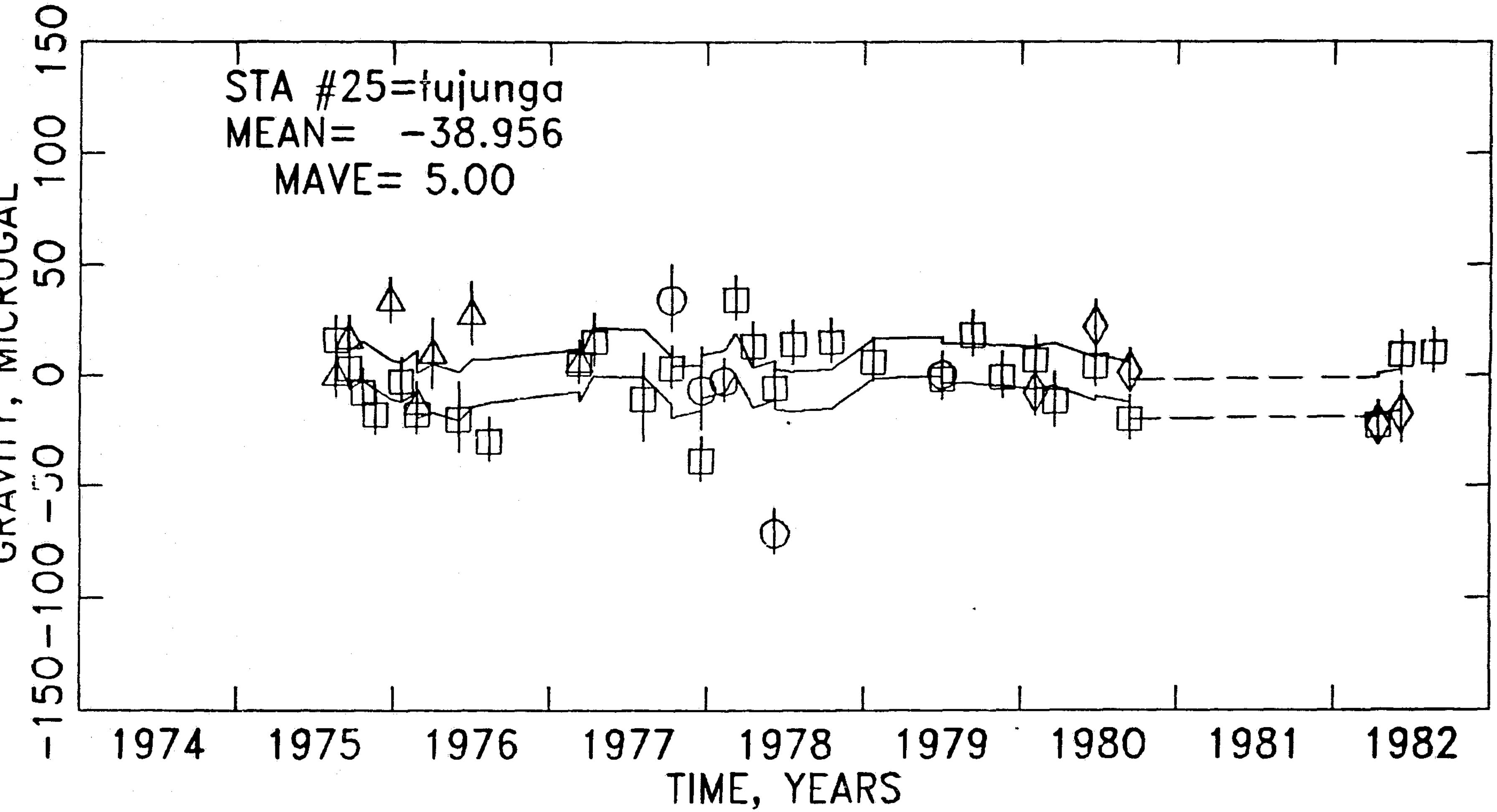
TIME, YEARS



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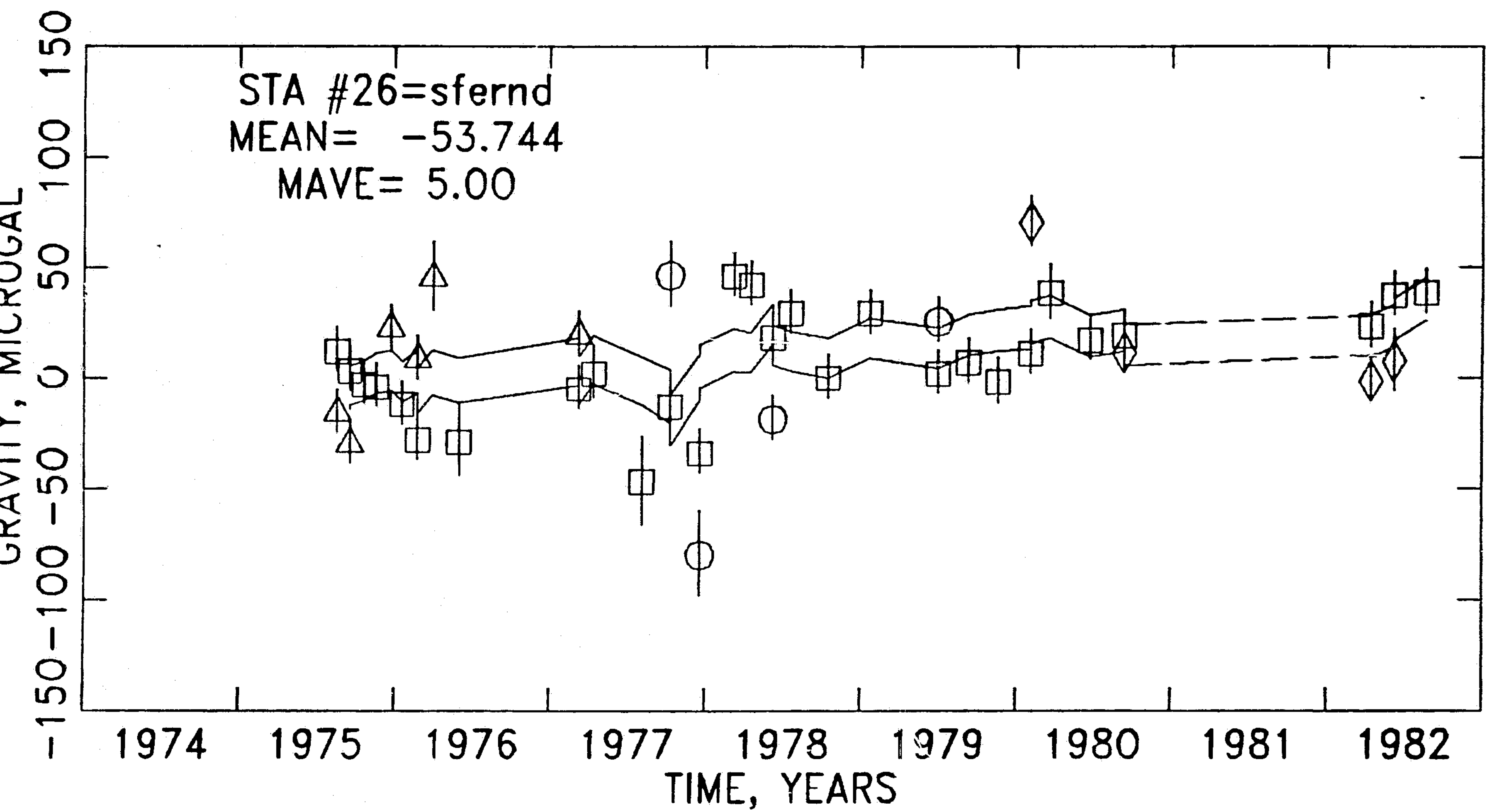

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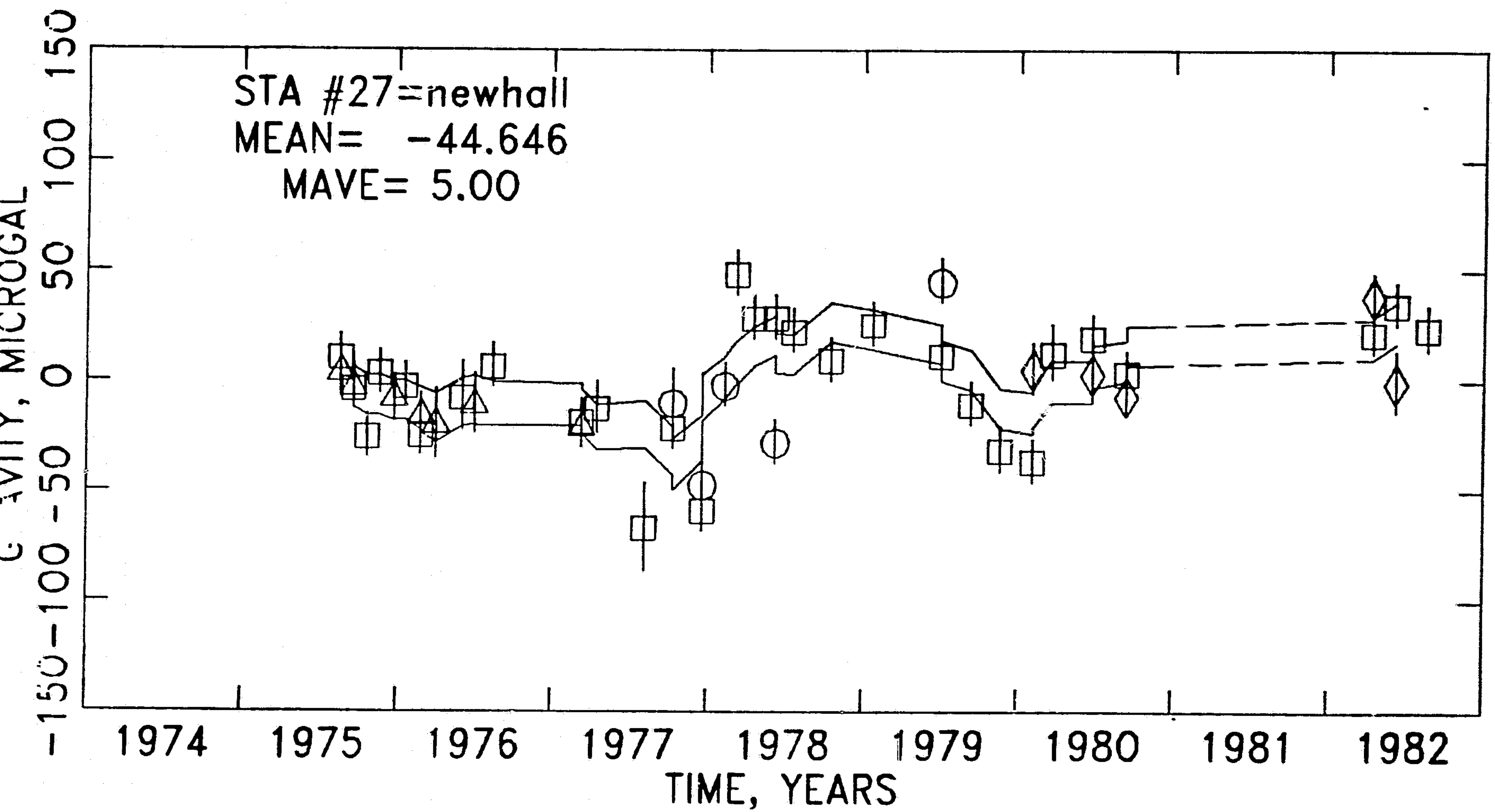
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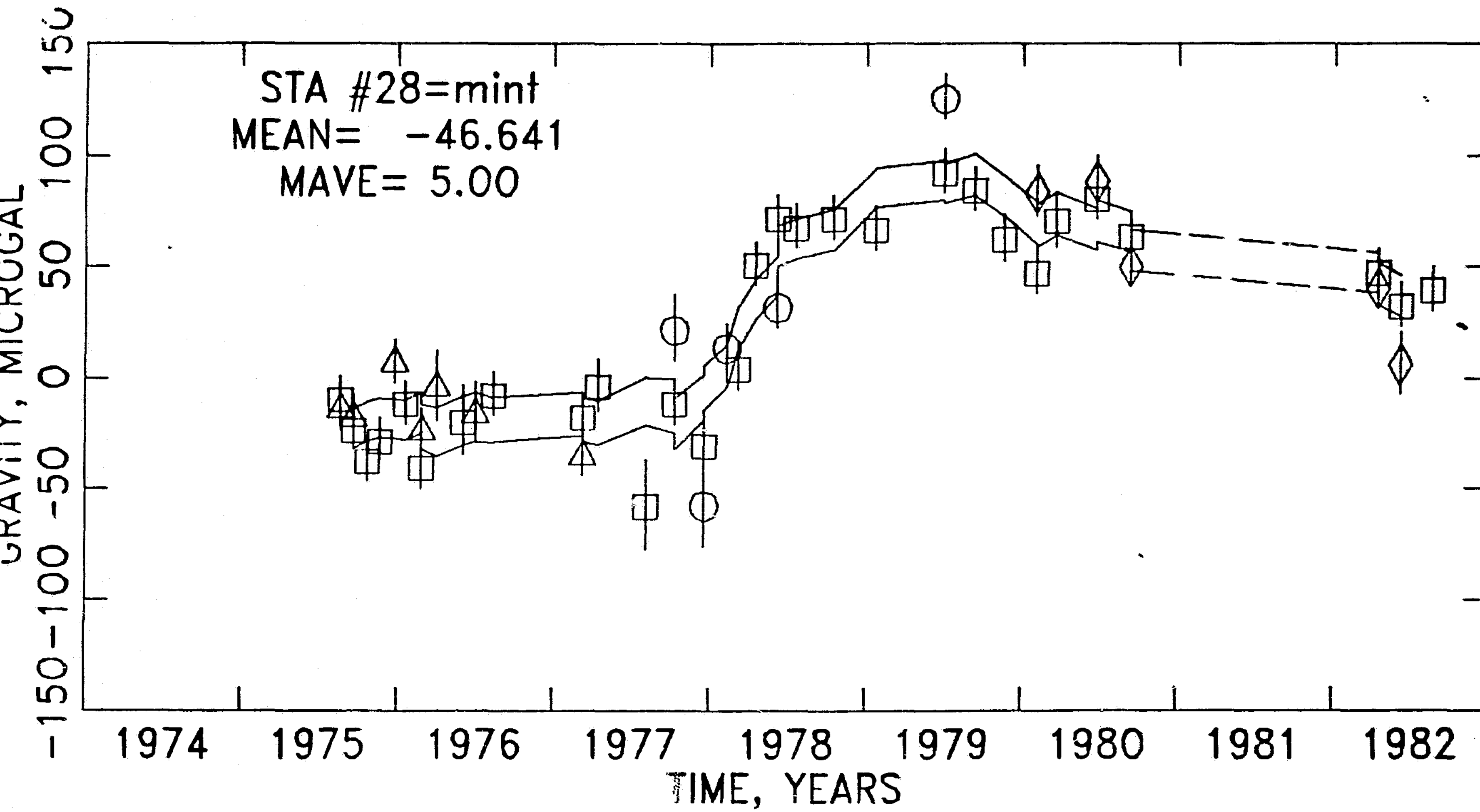
G AVITY, MICROGAL
-150 -100 -50 0 50 100 150
1974 1975 1976 1977 1978 1979 1980 1981 1982
TIME, YEARS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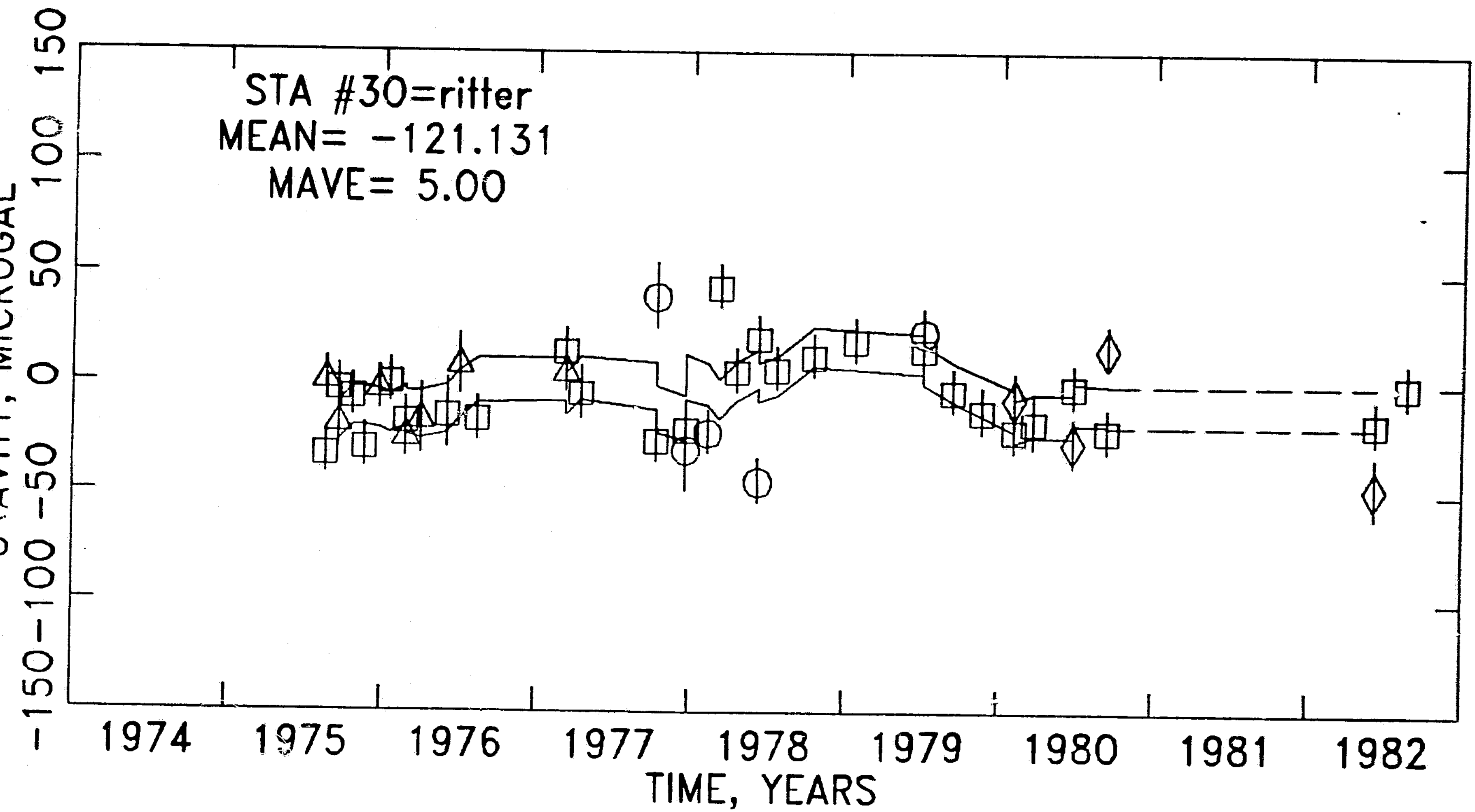
TIME, YEARS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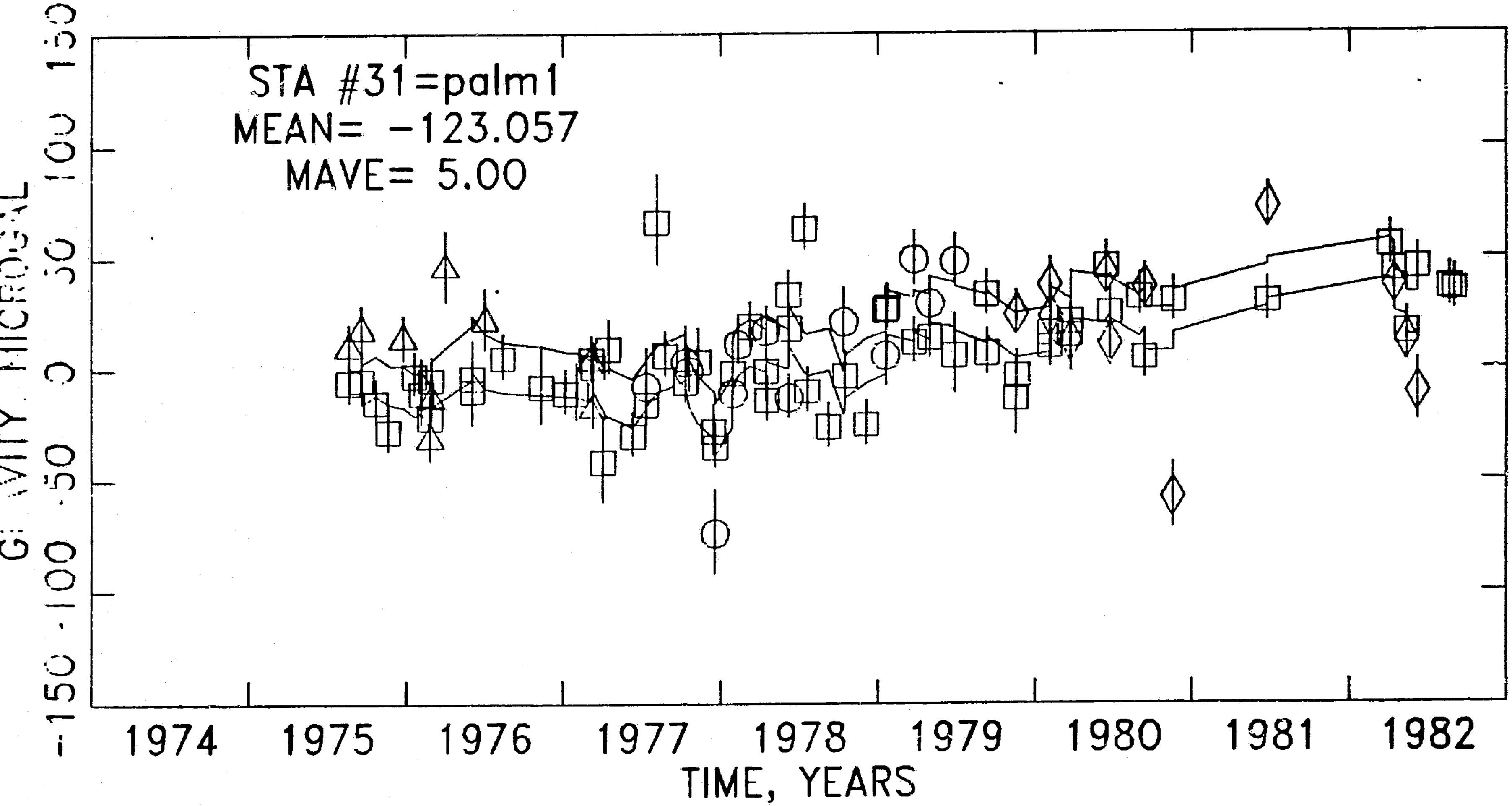
TIME, YEARS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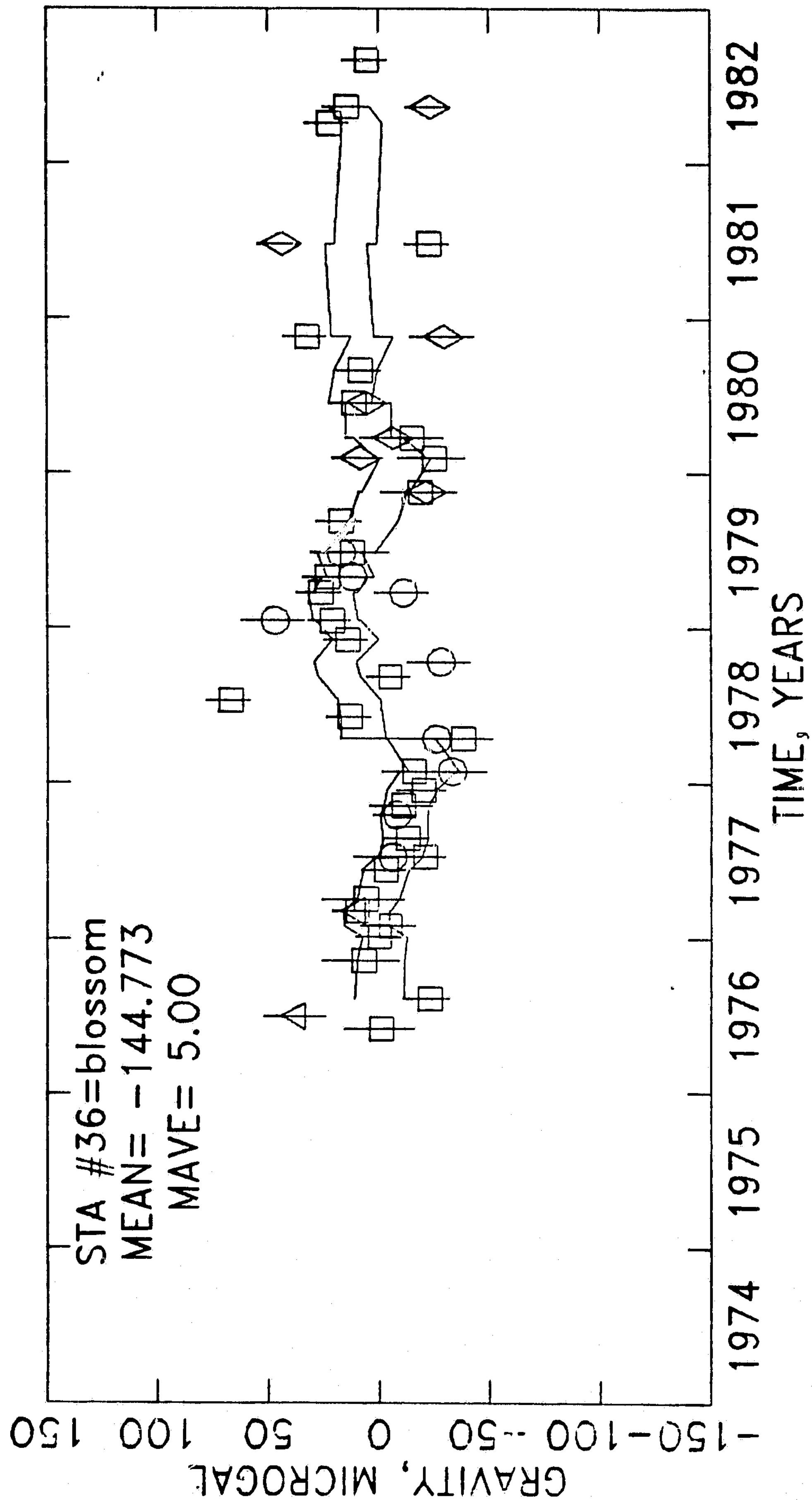
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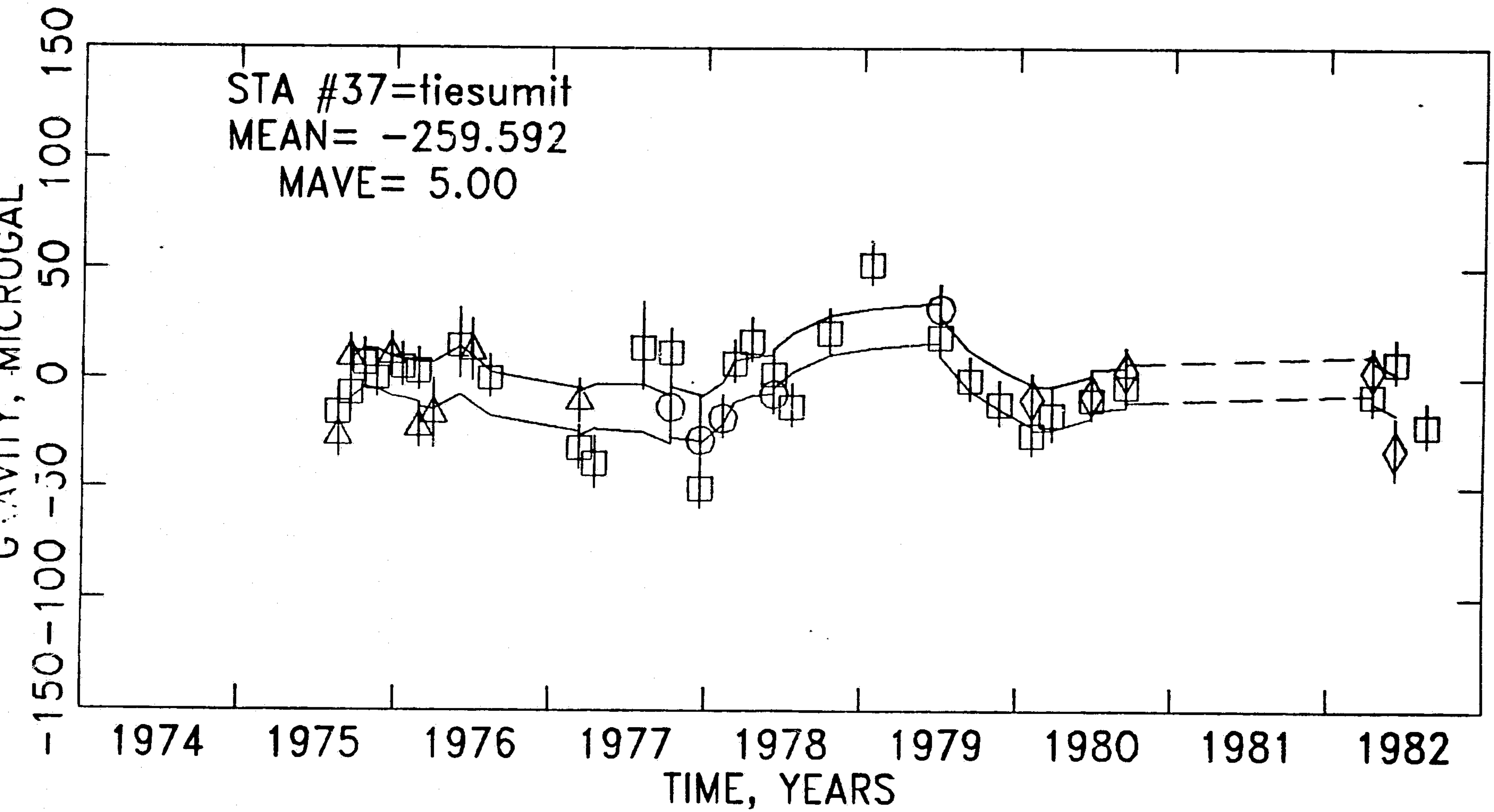
GRAVITY, MICROGAL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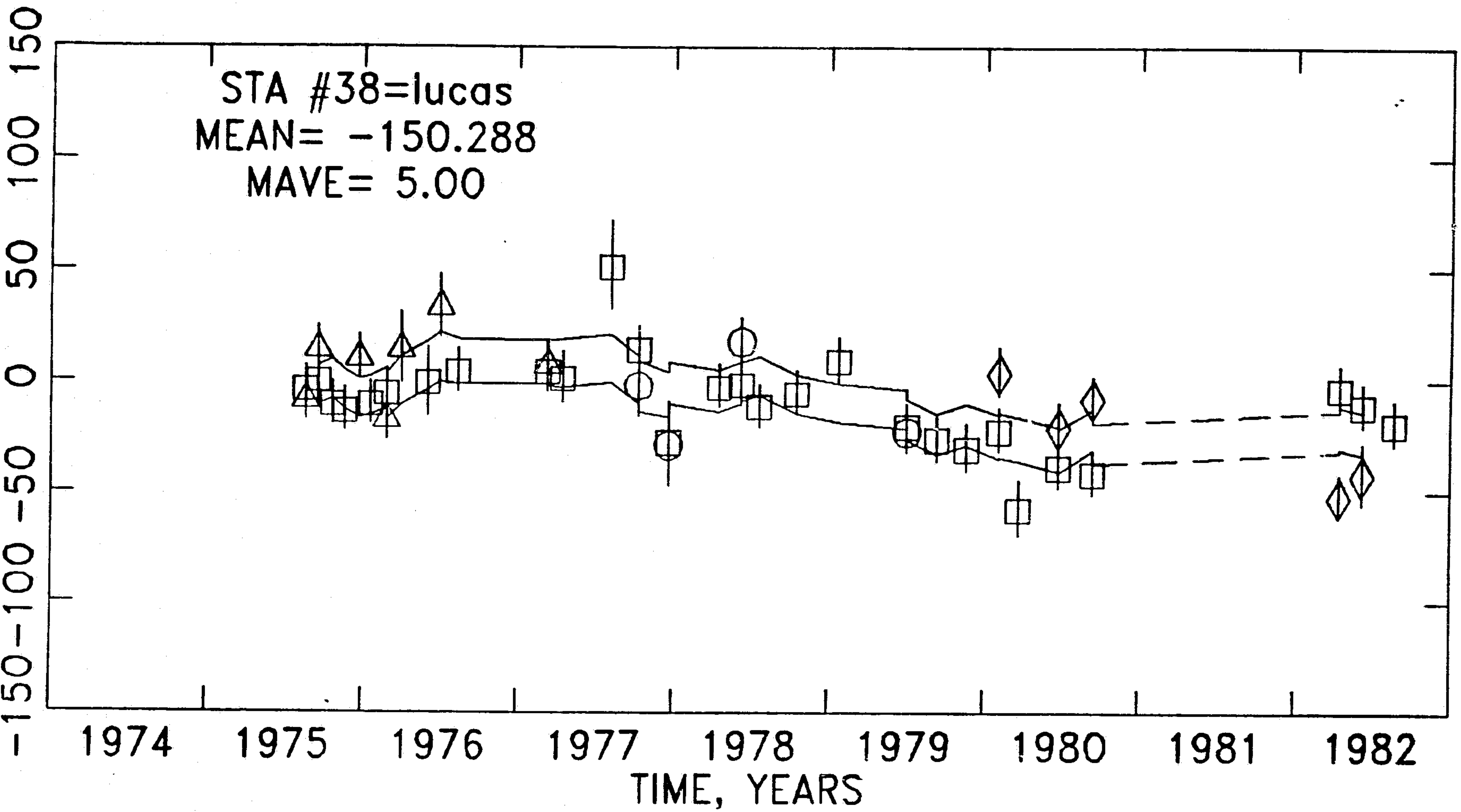
TIME, YEARS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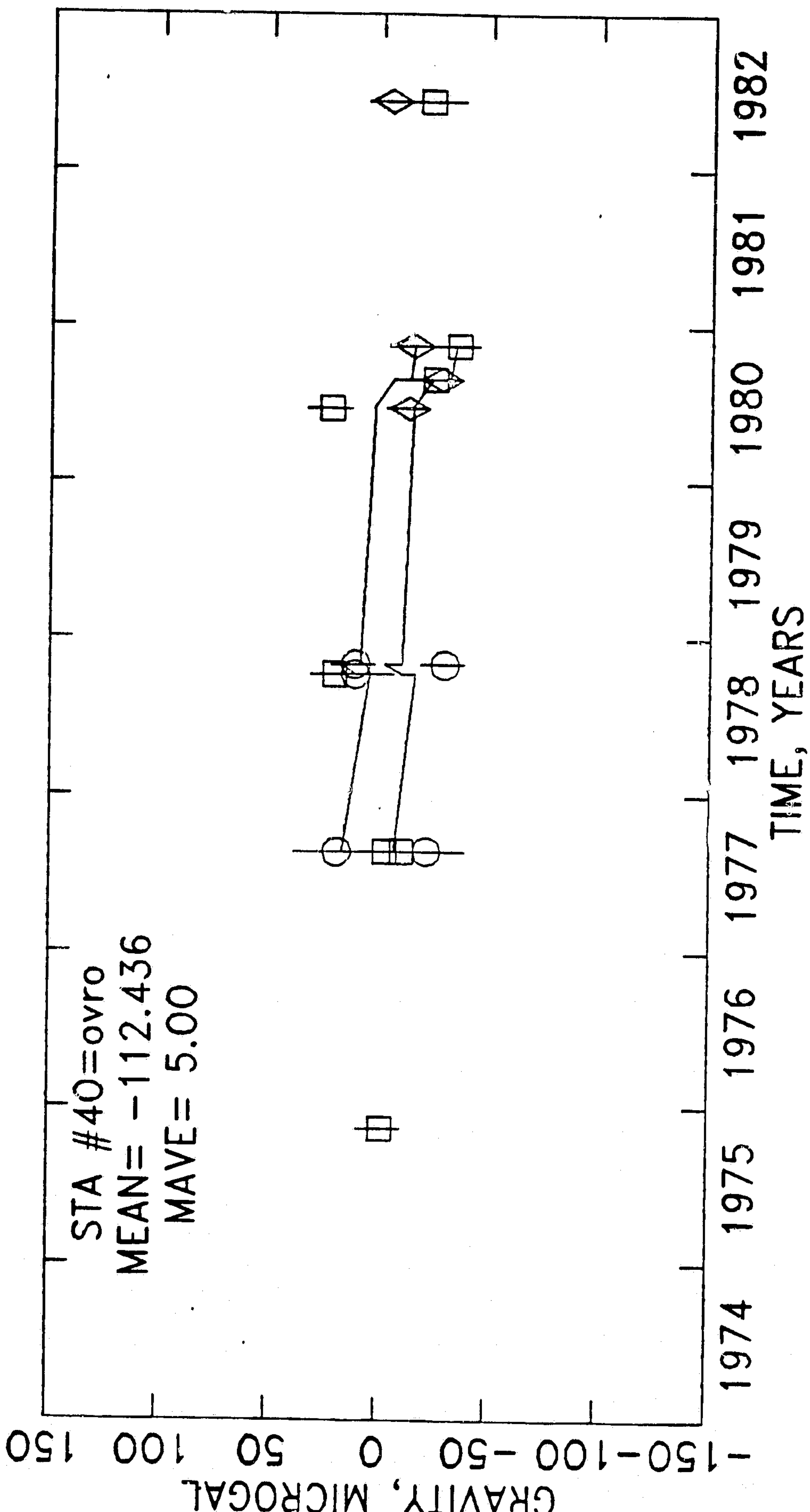
TIME, YEARS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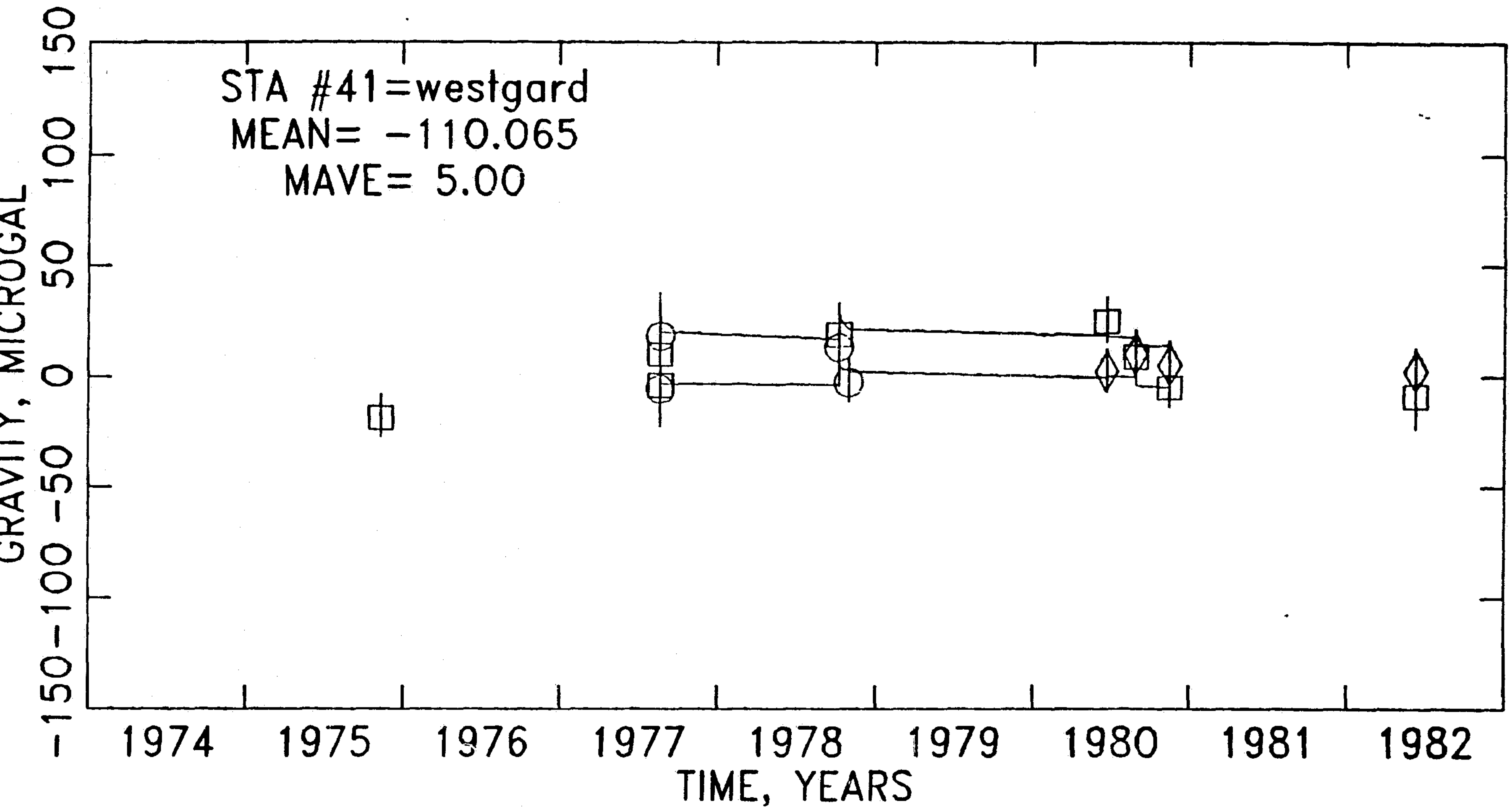
GRAVITY, MICROGAL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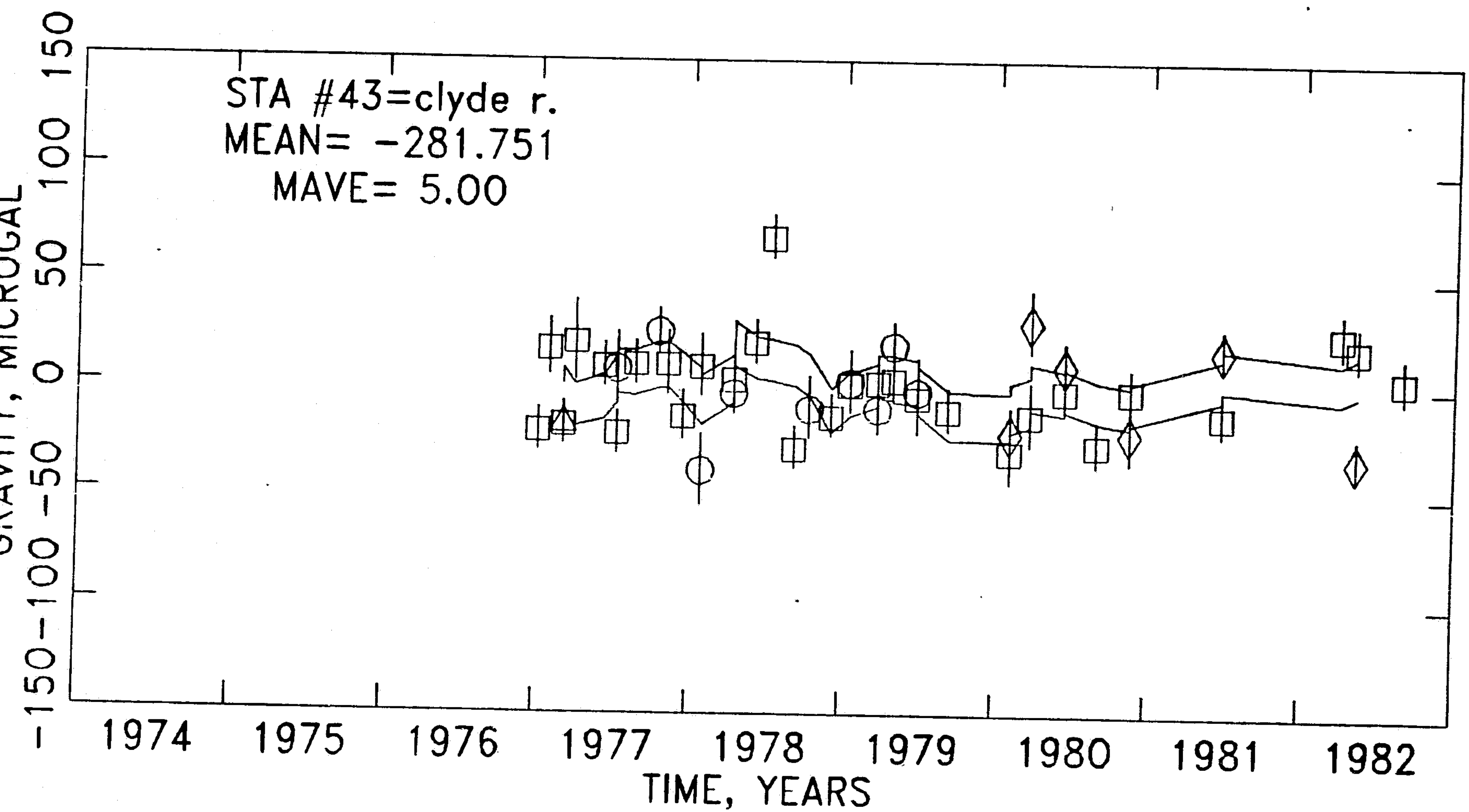
TIME, YEARS



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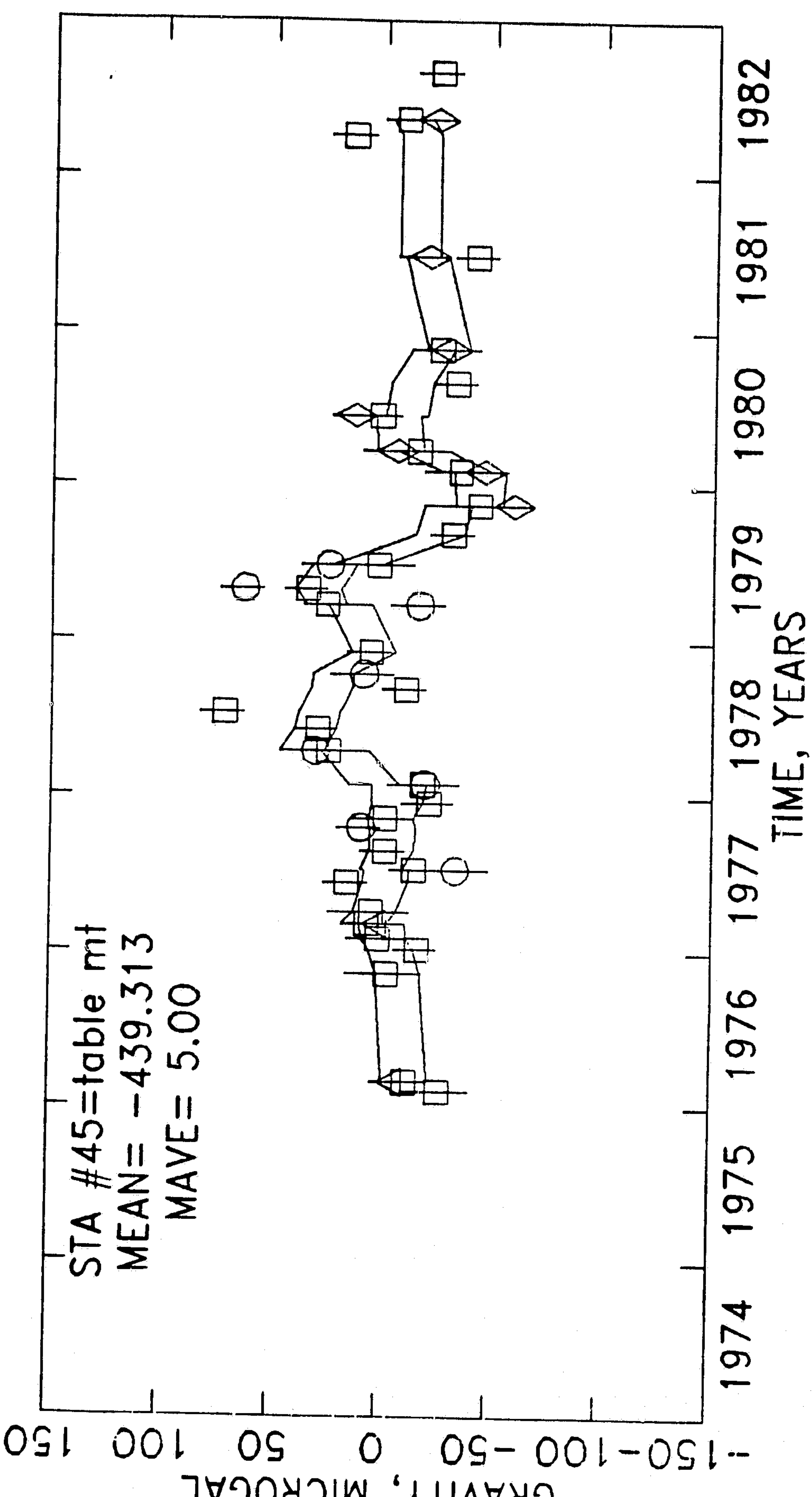
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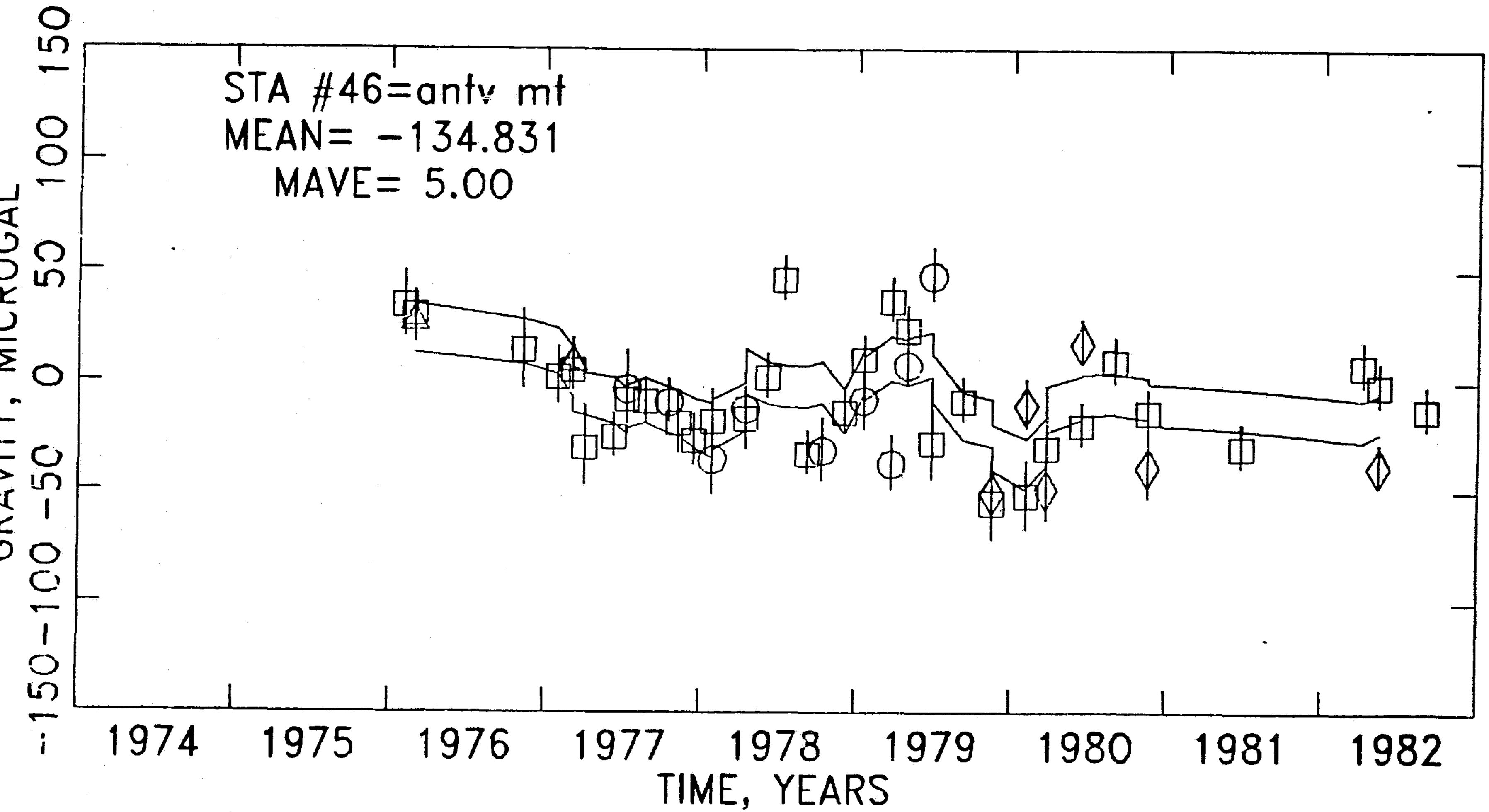
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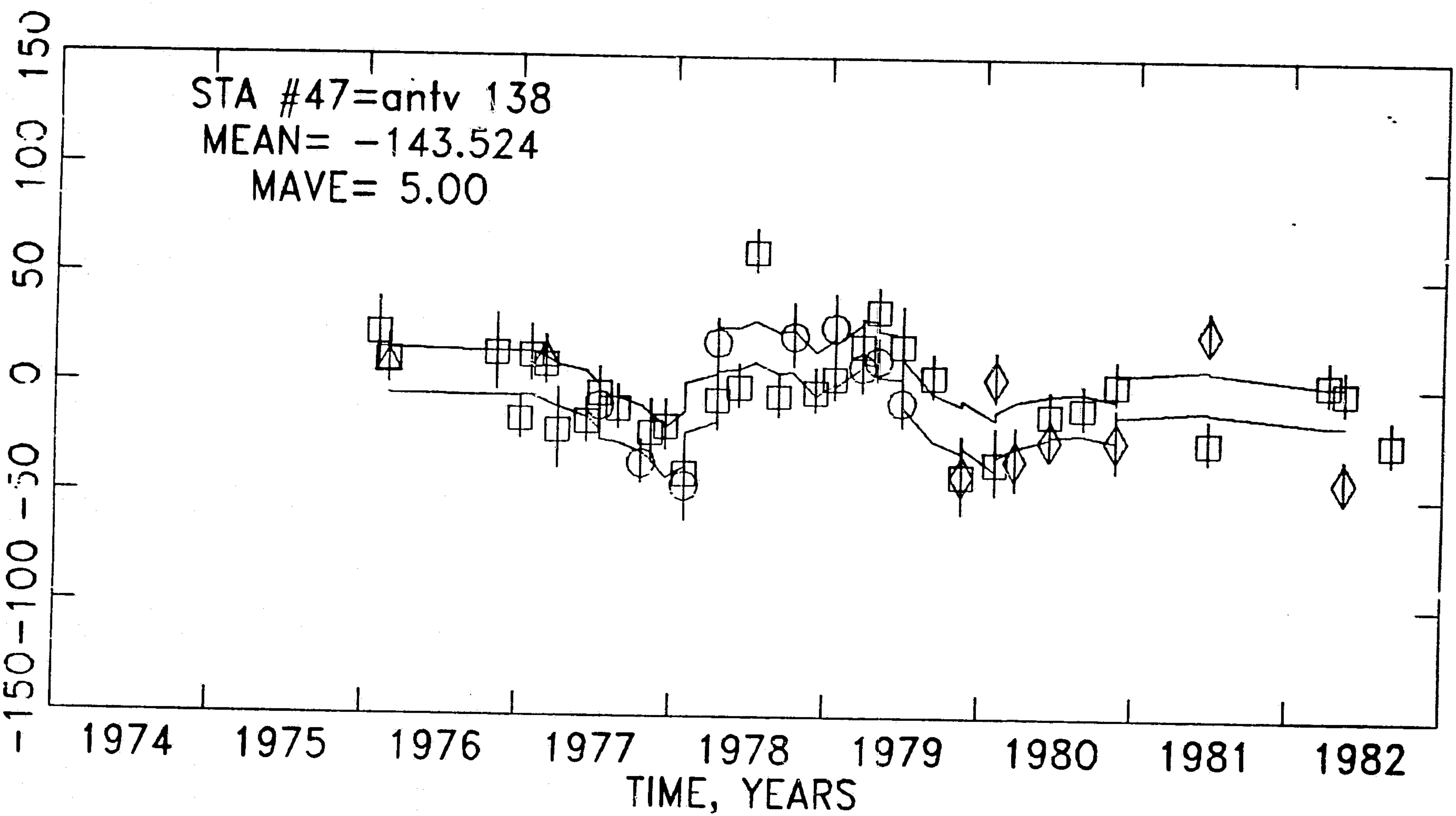
TIME, YEARS

22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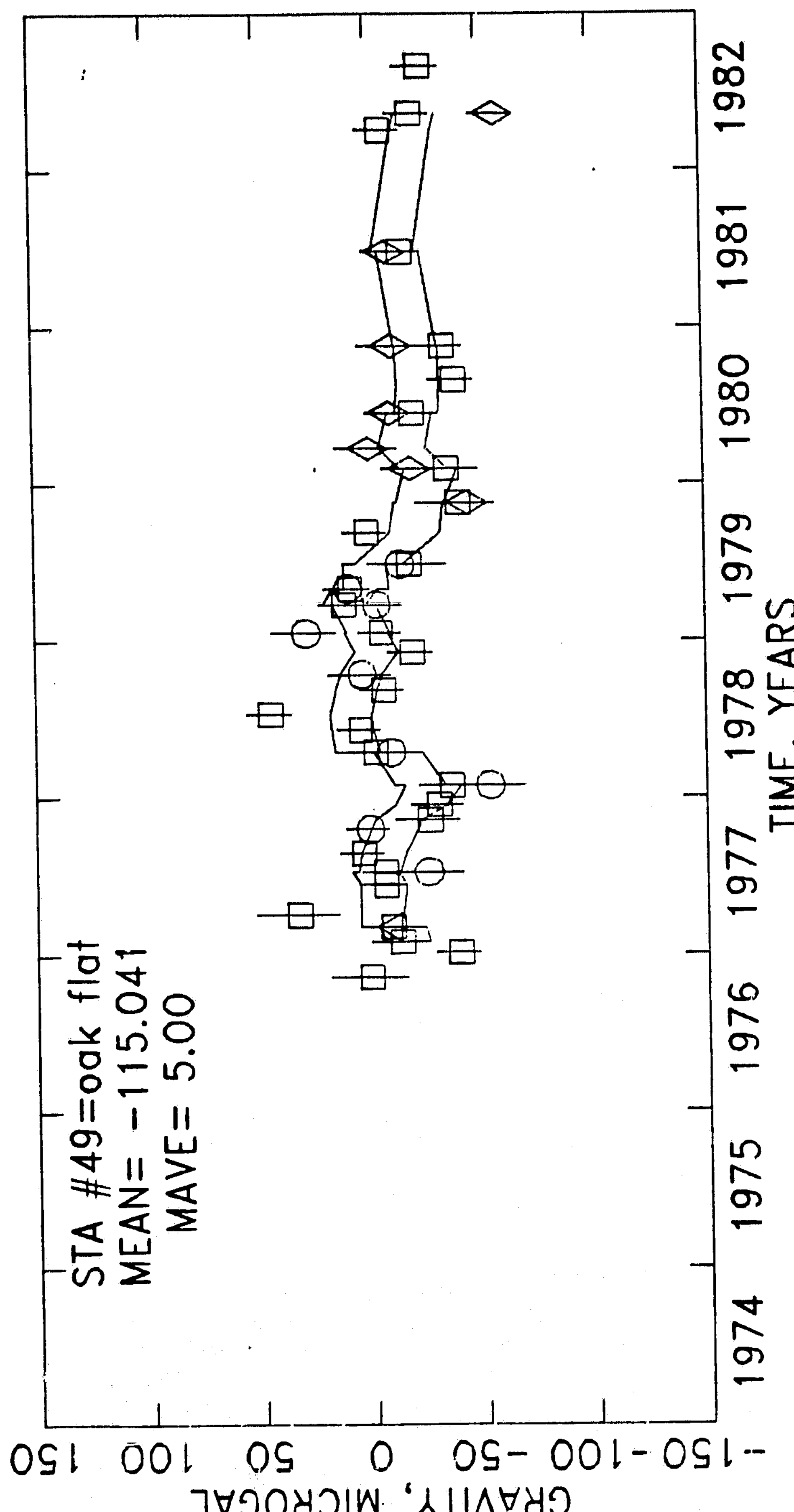
TIME, YEARS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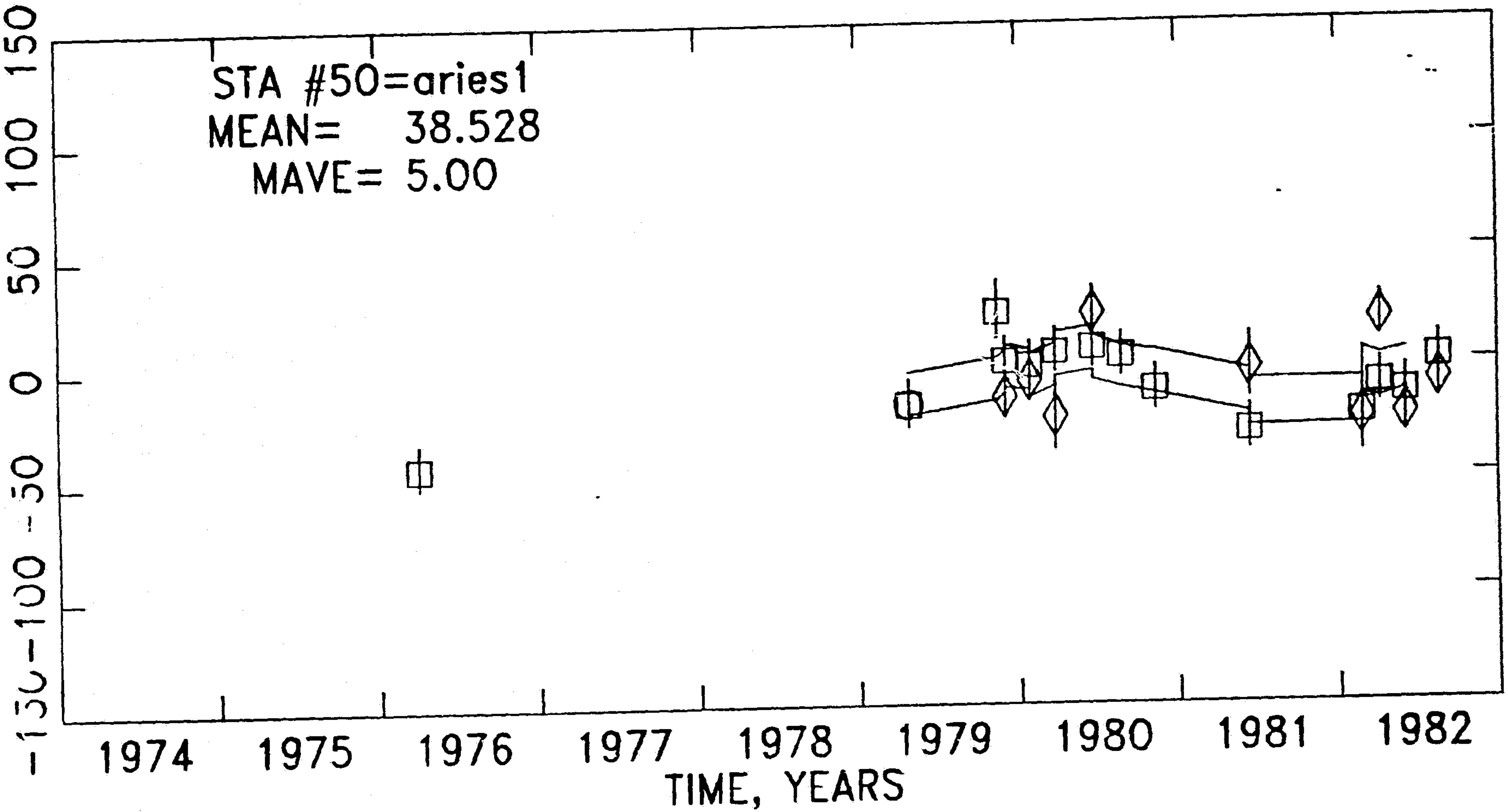
GRAVITY, MICROGAL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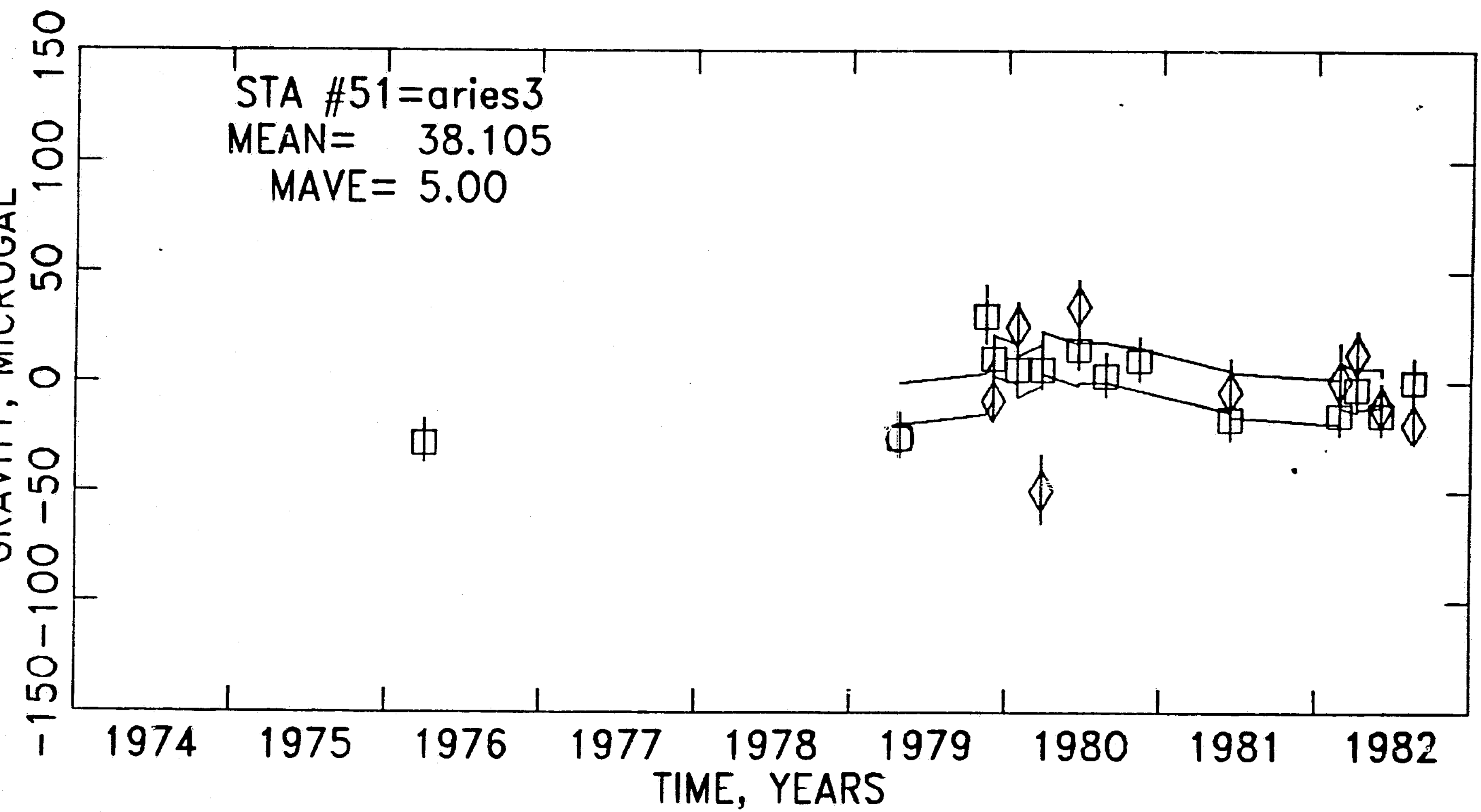
TIME, YEARS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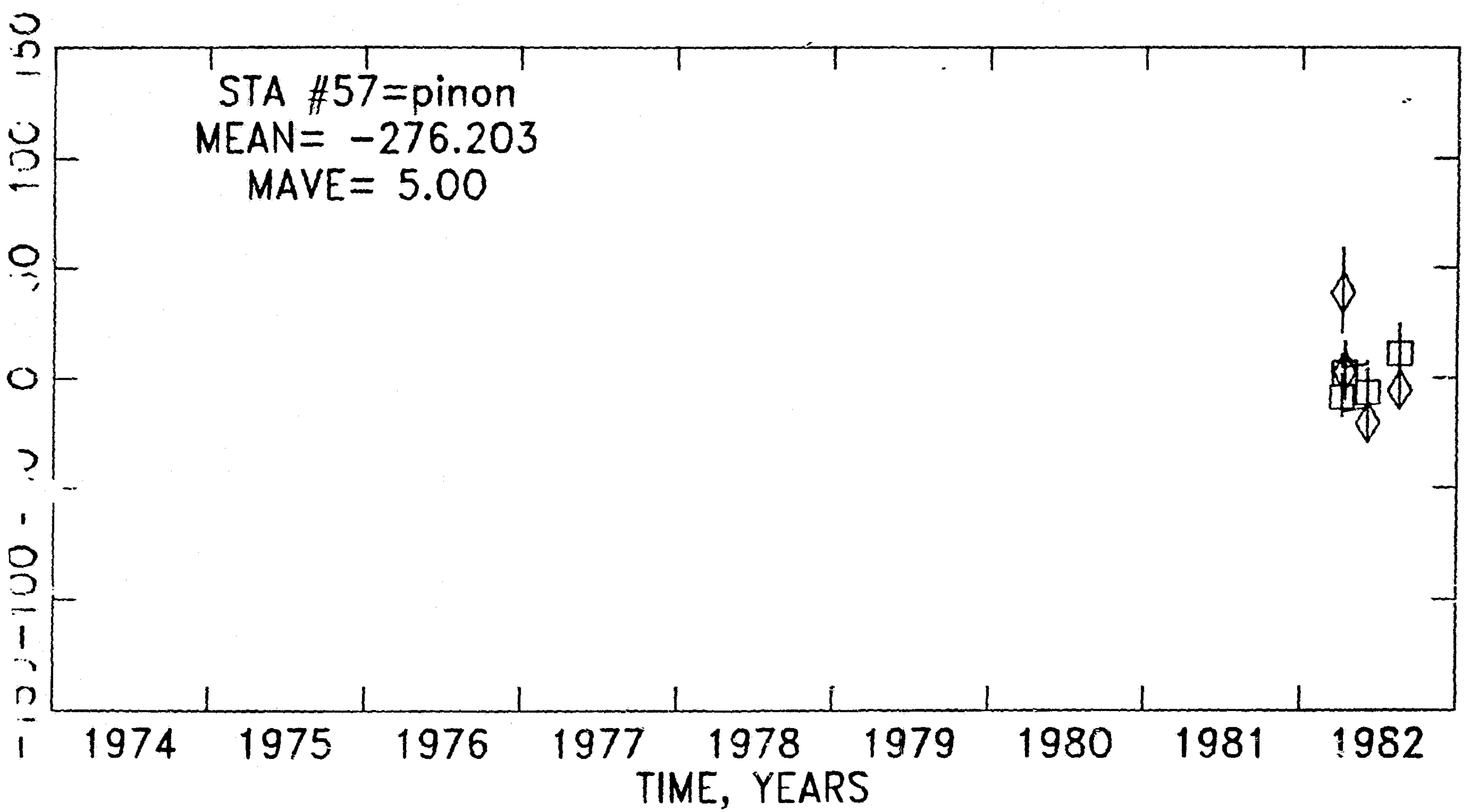
TIME, YEARS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TIME, YEARS