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ABSTRACT

A rifting episode started in 1975 on the constructive plate boundary in North Iceland after 100 years of quiescence. Horizontal drift movement of some 3 meters has been observed in the Krafla caldera and the associated 80 km long fissure swarm. The rifting occurs periodically in short active pulses at a few months intervals. Between these active pulses, continuous inflation of 7 to 10 mm per day of the caldera is caused by 5 m^3/sec inflow of magma into a magma chamber at 3 km depth. The active pulses are caused by a sudden east-west expansion of the fissure swarm and a contraction of zones outside the fissure swarm. Rapid flow of magma out of the magma chamber and into the fissures towards north or south is indicated. These pulses are accompanied by earthquake swarms and vertical ground movements of up to two meters and sometimes also volcanic eruptions and formation of new fumaroles. The magma chamber below the Krafla caldera thus acts as a trigger for the plate movement along the constructive plate boundary in North Iceland.

Key-words

Krafla volcano Iceland - Ground deformations - Plate boundary rifting.

INTRODUCTION

The plate boundary between the European and the American plates follows the Mid Atlantic Ridge and crosses Iceland from south-west to north-east. In Iceland, the boundary is characterized as zones of recent volcanism, graben structures and seismic activity, and is generally named the Neovolcanic Zone. The Neovolcanic Zone in north Iceland has a north-south direction and is characterized by several fault- and fissure swarms, each passing through a central volcano (Fig. 1). The tectonic and volcanic activity of the Neovolcanic Zone is restricted to these central volcanoes and the associated fissure swarms, and occurs episodically rather than continuously, with a period of 100 to 150 years. During each active period, which probably lasts 5 to 20 years, only one central volcano and fissure swarm is active (Björnsson et al. 1977).

The Krafla fissure swarm, which is presently active, extends from the Tjörnes Fracture Zone in the Axarfjördur bay in the north and some 100 km to the south. It´s width is approximately 5 km, but varies considerably along the swarm. It passes through the Krafla caldera, which formed during the last interglacial period, but has since been filled to the rim with eruptive material (Fig. 2). In post glacial time about 35 eruptions have taken place within this fissure swarm, most of them either within the Krafla caldera or in the Namafjall area, about 10 km south of Krafla (Björnsson et al. 1977).

A geothermal field with temperatures exceeding 340^{o}C at 2 km depth exists within the Krafla caldera, and another geothermal field located in the Namafjall area has a temperature exceeding 290^{o}C at 1.8 km depth. The economic importance of these geothermal fields is responsible for a more intense research of this area than would have been possible otherwise.

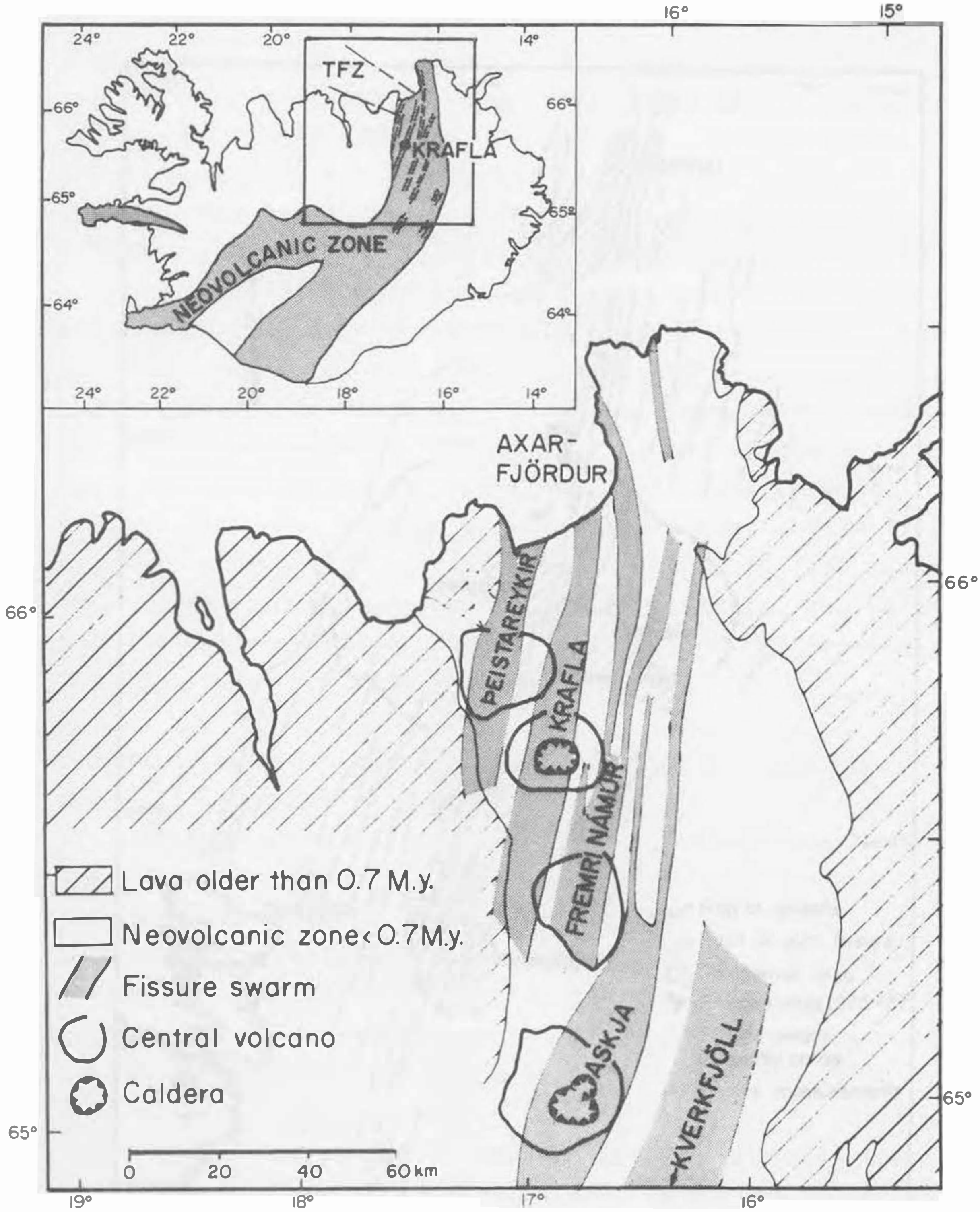

Fig. 1: The spreading zone in North Iceland. Central volcanoes and associated fissure swarms are named after the high-temperature geothermal fields in the central volcanoes. Two of them, Askja and Krafla, contain calderas. Mapped by Kristjan Saemundsson. The Tjörnes Fracture Zone (TFZ) is shown in the inlet.

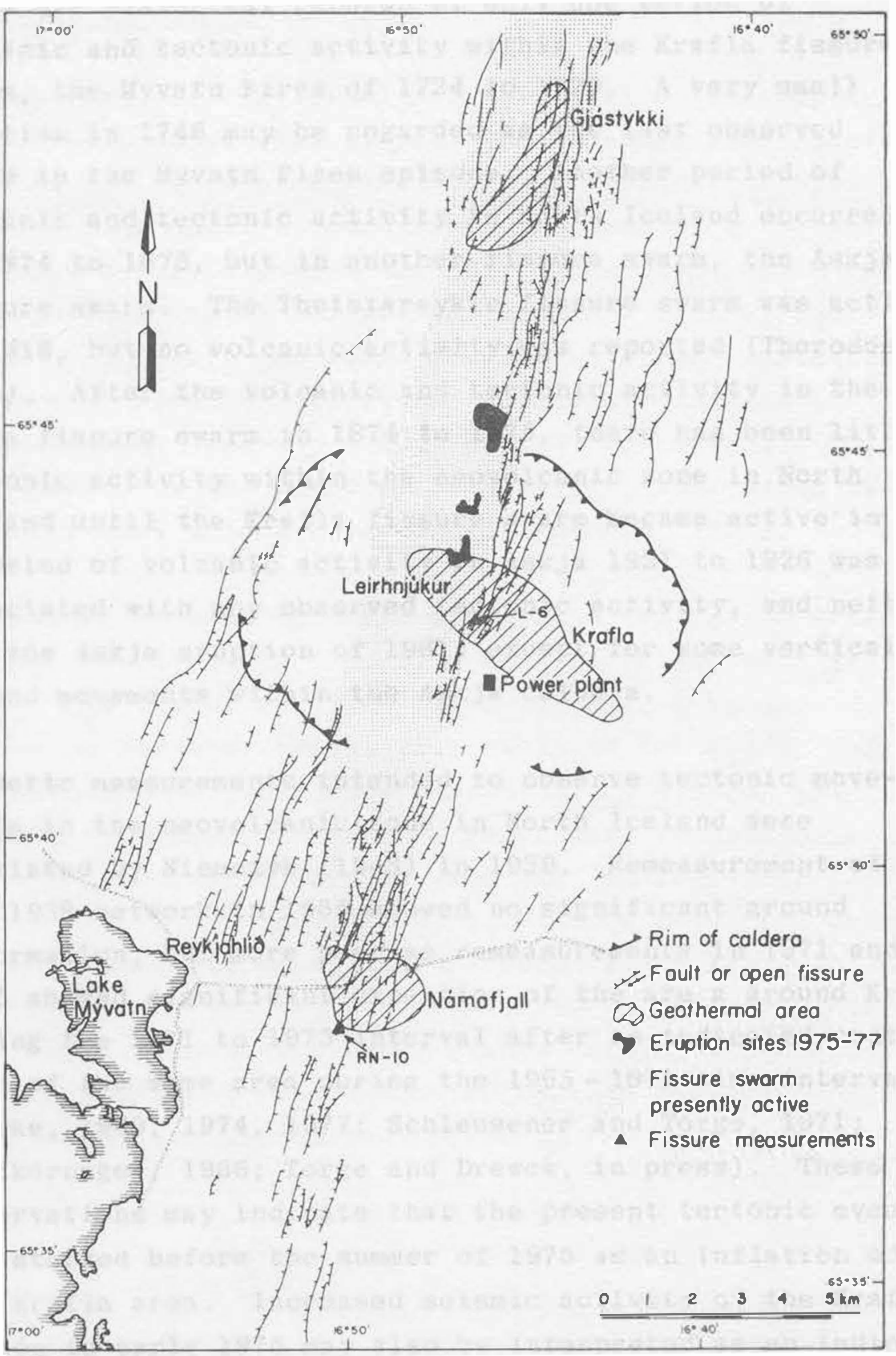

Fig. 2: Outline geological map of the Krafla caldera and the associated fissure swarm. Mapped by Kristjan Saemundsson.

There are historical records of only one period of volcanic and tectonic activity within the Krafla fissure swarm, the Myvatn Fires of 1724 to 1729. A very small eruption in 1746 may be regarded as the last observed pulse in the Myvatn Fires episode. Another period of volcanic and tectonic activity in North Iceland occurred in 1874 to 1875, but in another fissure swarm, the Askja fissure swarm. The Theistareykir fissure swarm was active in 1618, but no volcanic activity was reported (Thoroddsen, 1925). After the volcanic and tectonic activity in the Askja fissure swarm in 1874 to 1875, there has been little tectonic activity within the neovolcanic zone in North Iceland until the Krafla fissure swarm became active in 1975. A period of volcanic activity in Askja 1921 to 1926 was not associated with any observed tectonic activity, and neither was the Askja eruption of 1961, except for some vertical ground movements within the Askja caldera.

Geodetic measurements intended to observe tectonic movements in the neovolcanic zone in North Iceland were initiated by Niemczyk (1943) in 1939. Remeasurement of the 1938 network in 1965 showed no significant ground deformation, but more precise remeasurements in 1971 and 1975 showed significant expansion of the are a around Krafla during the 1971 to 1975 interval after an indicated contraction of the same area during the 1965 - 1971 time interval (Gerke, 1969, 1974, 1977; Schleusener and Torge, 1971; Spickernagel, 1966; Torge and Drewes, in press). These observations may indicate that the present tectonic event had started before the summer of 1975 as an inflation of the Krafla area. Increased seismic activity of the Krafla region in early 1975 may also be interpreted as an indication of abnormal tectonic activity.

NARRATIVE OF EVENTS

Contemporary description of the Myvatn Fires episode in 1724 to 1729 shows clearly that the volcanic and seismic activity was largely confined to short periods of high activity interupted by much longer periods of quiescence. Each active period lasted for only a few days, while the quiet periods lasted for several months. Each of the pulses of activity was characterized by strong earthquakes and either volcanic activity or noticeable changes in the geothermal activity. Some of the pulses were associated with changes in the level of Lake Myvatn, indicating large scale vertical ground movement (Thoroddsen, 1925).

The present volcano-tectonic episode in the Myvatn-Krafla area is also characterized by a similar pulsation. It is possible to divide the time since the active episode started in December 1975 into periods of two kinds, inflation periods and subsidence events. Fig. 3 shows the elevation changes with time of bench mark FM-5596 near the center of the Krafla caldera (see Fig. 5) from 1975 to early 1978. Since the initial subsidence event, in December 1975, the rate of uplift has been relatively constant, around 7 mm per day at this point, but it has been interupted by 7 sudden subsidence events lasting 2 hours to several days each. The inflation periods last for one to seven months and are characterized by:

1) Continuous and nearly constant uplift of the Krafla region. The maximum uplift is near the center of the caldera, 7 - 10 mm per day, decreasing outwards to less than 1 mm per day at a distance of 10 km from the apex of uplift.
2) Gradually increasing seismic activity within the caldera after the land elevation has reached a certain critical level. Decreasing or no seismic activity within the fissure swarm outside the caldera (P.Einarsson, personal communication).

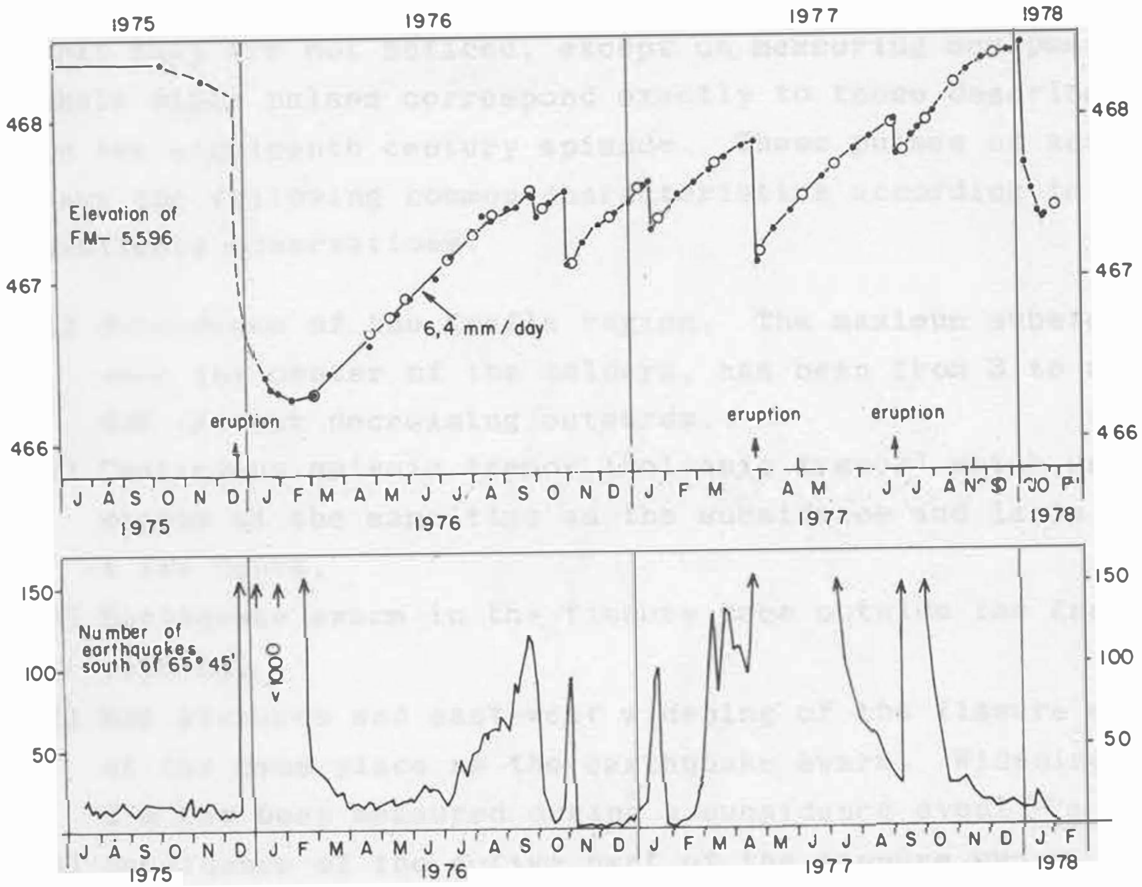

Fig. 2: Changes in elevation of bench mark FM-5596 within the Krafla caldera from 1975 to early 1978. Levelling data (open circles) are supplemented with tilt data at the Krafla power house (dots). The rate of uplift is relatively constant, 5 to 7 mm per day, interrupted by 8 sudden subsidence events. The subsidence event of November 2, 1977, was too small to be shown on this graph. The lower part shows running five days average number of earthquakes within and south of the Krafla caldera. After April 27, 1977, most of the earthquakes occurred south of the caldera. The earthquake information was kindly supplied by P. Einarsson.

3) Gradual widening of fissures near the center of uplift, up to 1 mm per day.

The duration of the subsidence events or active pulses is much shorter than the inflation periods. Some are so small that they are not noticed, except on measuring equipment, while other pulses correspond exactly to those described in the eighteenth century episode. These pulses of activity have the following common characteristics according to the available observations:

1) Subsidence of the Krafla region. The maximum subsidence, near the center of the caldera, has been from 3 to about 250 cm, but decreasing outwards.
2) Continuous seismic tremor (volcanic tremor) which usually starts at the same time as the subsidence and lasts for a few hours.
3) Earthquake swarm in the fissure zone outside the Krafla caldera.
4) New fissures and east-west widening of the fissure swarm at the same place as the earthquake swarm. Widening of 2 m has been measured during a subsidence event (Fig. 4)
5) Subsidence of the active part of the fissure swarm, sometimes exceeding one meter, and uplift of both flanks of the swarm amounting to tens of centimeters.
6) Development of new geothermal areas or increased activity in old ones. Increased pressure in drillholes.
7) Outpouring of basaltic lava, mostly within the caldera, has been observed in three of the active pulses.

The first pulse of high activity started on December 20, 1975 and lasted for several weeks. The maximum subsidence, near the center of the caldera, was some 2.5 m and intense earthquake swarm was observed some 40 to 60 km north of Krafla where large scale ground movements occurred (Björnsson, 1976, Björnsson et al., 1977; Tryggvason, 1976).

The second period of activity started about September 29,

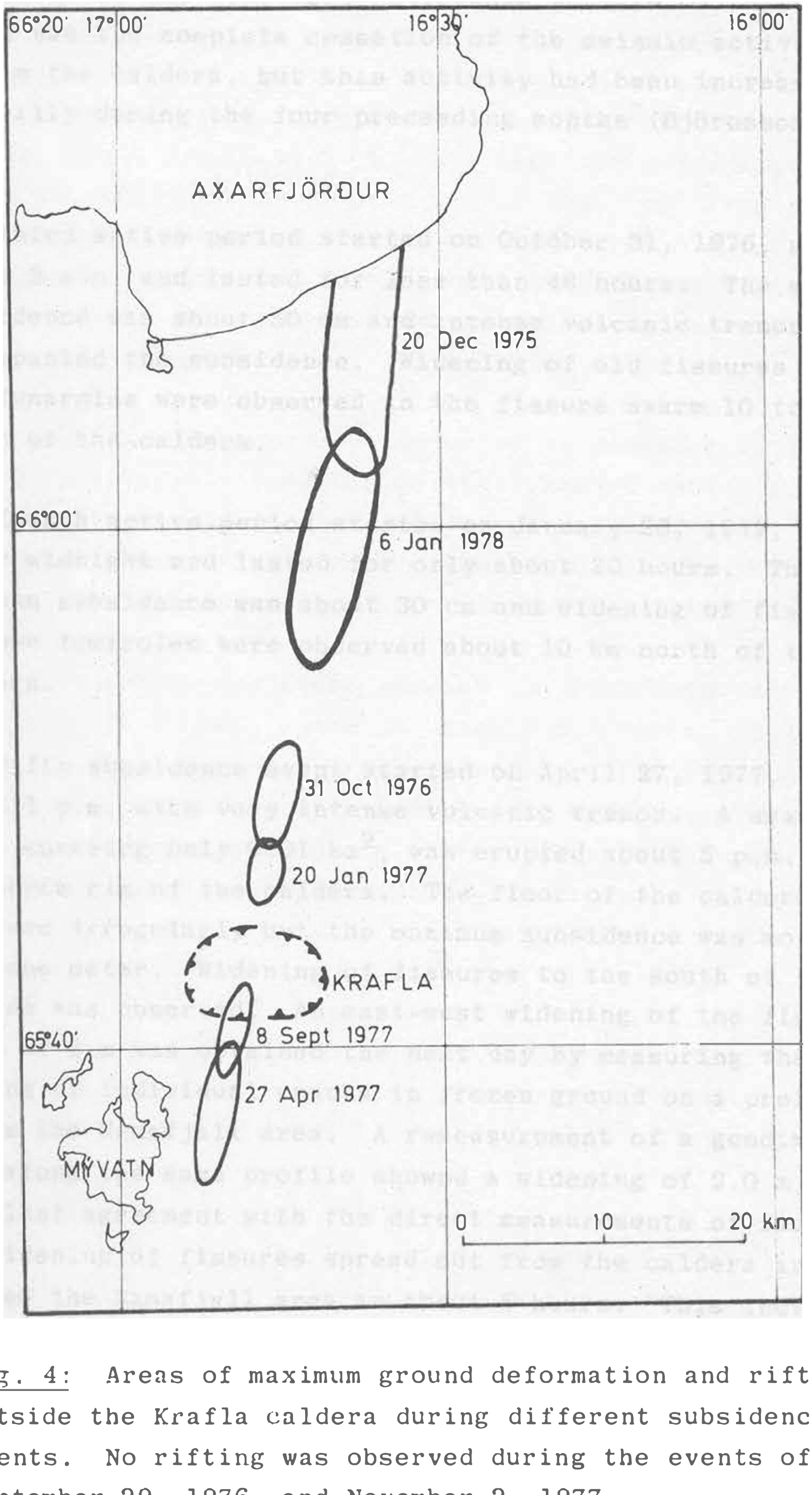

Fig. 4: Areas of maximum ground deformation and rifting outside the Krafla caldera during different subsidence events. No rifting was observed during the events of September 29, 1976, and November 2, 1977.

1976. It lasted for some 5 days and the maximum subsidence was about 15 cm. The most noticeable feature of this pulse was the complete cessation of the seismic activity within the caldera, but this activity had been increasing gradually during the four preceeding months (Björnsson et al., 1977).

The third active period started on October 31, 1976, at about 2 a.m. and lasted for less than 48 hours. The maximum subsidence was about 50 cm and intense volcanic tremor accompanied the subsidence. Widening of old fissures and new fumaroles were observed in the fissure swarm 10 to 15 km north of the caldera.

The fourth active period started on January 20, 1977, shortly after midnight and lasted for only about 20 hours. The maximum subsidence was about 30 cm and widening of fissures, and new fumaroles were observed about 10 km north of the caldera.

The fifth subsidence event started on April 27, 1977, at about 1 p.m. with very intense volcanic tremor. A small lava, covering only 0.01 km^2, was erupted about 5 p.m. near the north rim of the caldera. The floor of the caldera subsided irregularly but the maximum subsidence was more than one meter. Widening of fissures to the south of the caldera was observed. An east-west widening of the fissure swarm of 2 m was obtained the next day by measuring the opening of individual cracks in frozen ground on a profile across the Namafjall area. A remeasurement of a geodimeter line along the same profile showed a widening of 2.0 m in excellent agreement with the direct measurements of fissures. The widening of fissures spread out from the caldera and reached the Namafjall area in about 5 hours. This indicates a velocity of the order of 0.5 m/sec for the horizontal movement of activity. During this active pulse the central part of the active fissure swarm subsided about one meter but the flanks to the east and west were uplifted some tens of centimeters (fig. 6).

The sixth subsidence event started with volcanic tremor around 4 p.m. on September 8, 1977. The course of events was very similar as on April 27. A volcanic eruption started at about 6 p.m. near the north rim of the caldera. The area covered with lava was about 0.8 km^2 and the volume of lava is estimated as $2 \cdot 10^6$ m^3. Another volcanic eruption occurred about 11.^{45} p.m. in the Namafjall area where some 2500 kg of basaltic pumice erupted through a borehole, 1138 m deep. This location is about 12 km south of the lava eruption, in the fissure swarm where the east-west widening was one meter.

The seventh subsidence event occurred on November 2, 1977, and was the least noticeable of the observed active periods to date. It lasted for only two hours and the total subsidence was 2 - 3 cm. Small tremor was seen on the local seismometers but no movement on fissures was observed.

The eighth subsidence event started in the afternoon of January 6, 1978, and lasted for some three weeks. The maximum subsidence within the caldera during this event exceeded one meter and the accompanying earthquake swarm was strongly felt 20 to 50 km north of Krafla, where significant subsidence and widening of fissures was observed.

THE OBSERVATIONS, TECHNIQUES AND DATA

The credibility of the observed ground deformation and the interpretations based thereon are entirely dependent on the nature and extent of the measurements. Therefore, it is certainly in order to give some details of the observational techniques and procedures along with the presentation of data. Only those observations which are pertinent in analysing the tectonic processes are described.

Levelling

Levelling was carried out in 1974 and earlier along the road from Myvatn to Krafla and around the geothermal field at Krafla. This levelling network was extended in 1976 and includes presently about 70 bench marks. Levelling has been performed at intervals of one to two months since March 1976 in a large part of this network and at longer intervals in the remainder. Zeiss Ni2 level and wooden measuring rods, compared with Wild invar rods, are used. The standard error of the levelling has been determined as approximately $1.5 \cdot \sqrt{L}$ mm, where L is the length of the foreward and backward measured levelling line in kilometers.

The area which has been rising and subsiding in the Krafla region has remained nearly constant during the last two years. The inflation bulge and the deflation bowl is nearly circular, although east-west elongation is indicated. Maximum vertical ground movement is observed near the center of the caldera. The half-width of the bowl or bulge is about 3 km and only very minor movement is measured at 10 km distance from the center. Some details of the inflation-deflation pattern are shown in Fig. 5.

The elevation changes within and around the Krafla caldera

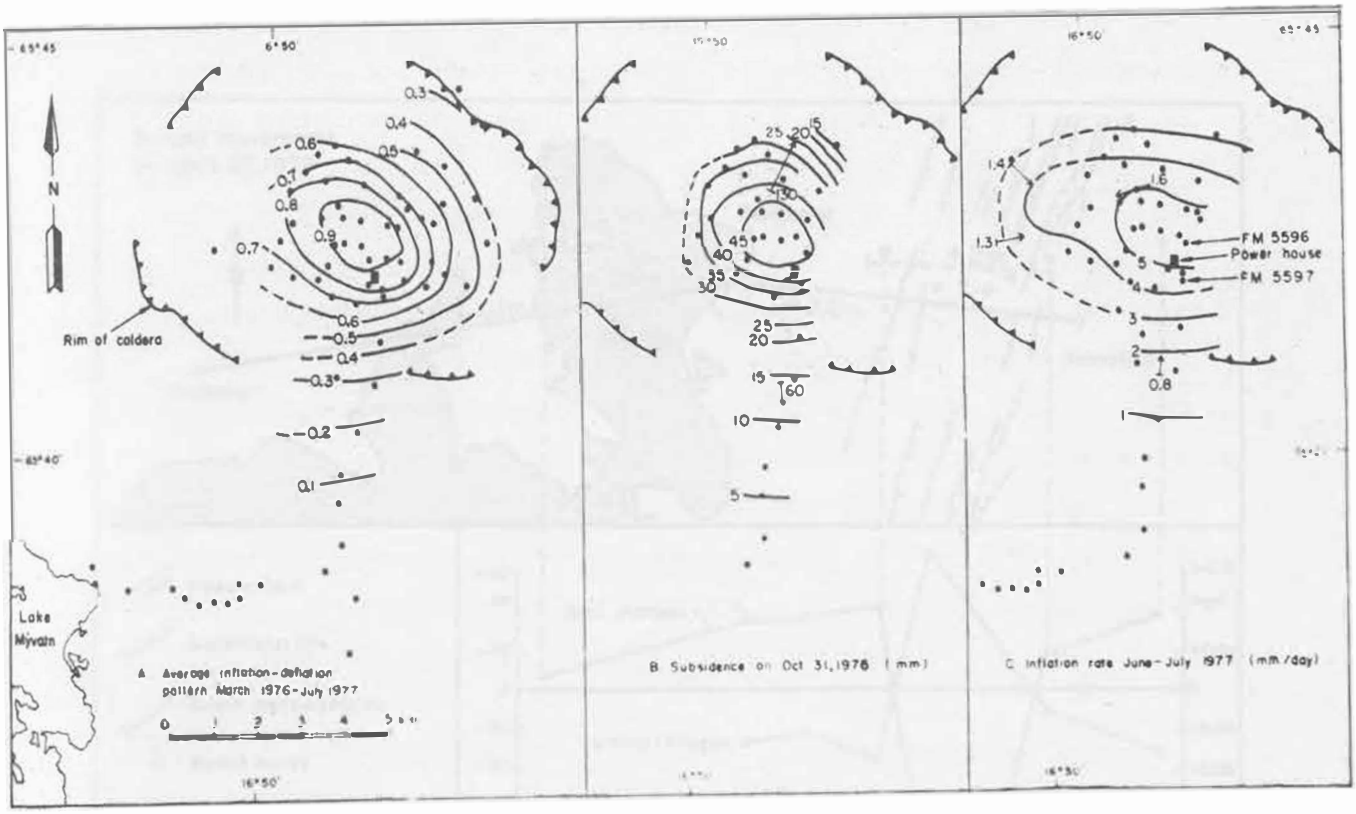

Fig. 5: Pattern of uplift and subsidence in the Krafla area. A shows the normalized average vertical ground movement throughout the period March 1976 to July 1977. B shows the total subsidence in centimeters during the subsidence event of October 31 to November 1, 1976. C shows the rate of uplift in millimeters per day during a period of one month, June to July 1977. The arrows show tilt changes in microradians at four stations.

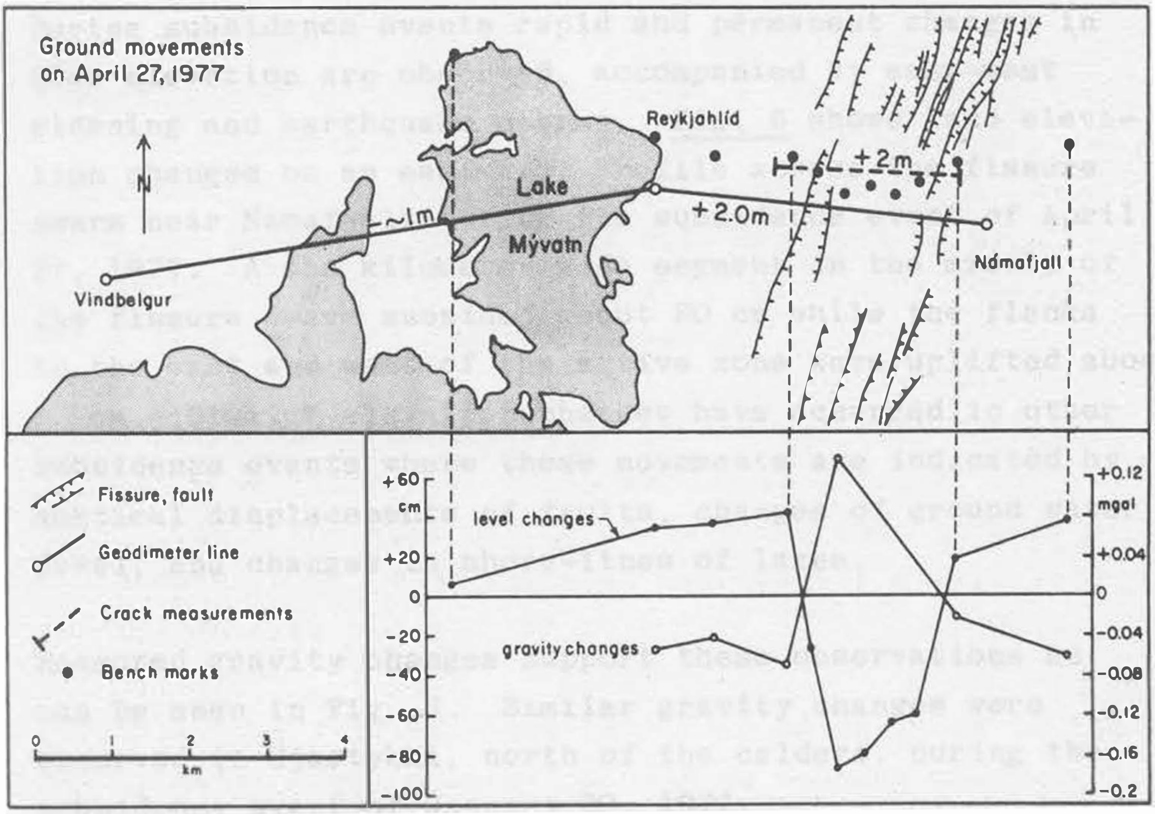

Fig. 6: Horizontal and vertical ground movements across the Krafla fissure swarm by Namafjall during the subsidence event of April 27, 1977. Expansion is measured on individual cracks and by geodimeter. Elevation and gravity changes are shown in the lower part of the figure.

have been cyclic up and down movements (Fig. 3) while elevation changes on the fissure swarm to the south and north of the caldera are more or less transient phenomena. During subsidence events rapid and permanent changes in land elevation are observed, accompanied by east-west widening and earthquake swarms. Fig. 6 shows land elevation changes on an east-west profile across the fissure swarm near Namafjall during the subsidence event of April 27, 1977. A one kilometer wide segment in the middle of the fissure swarm subsided about 80 cm while the flanks to the east and west of the active zone were uplifted about 30 cm. Similar elevation changes have occurred in other subsidence events where these movements are indicated by vertical displacements of faults, changes of ground water level, and changes in shore-lines of lakes.

Measured gravity changes support these observations as can be seen in Fig. 6. Similar gravity changes were observed in Gjastykki, north of the caldera, during the subsidence event of January 20, 1977.

Tilt measurements

A water tube tiltmeter was installed on a semi permanent basis in the Krafla power house on August 19, 1976. Three measuring pots are connected. The north-south arm of this tiltmeter is 68.95 m long and the east-west arm 19.50 m. The reading accuracy is better than 1 microradian but temperature variations and corresponding thermal expansions of the building cause tilt error of the same magnitude. These can be partly corrected for. Readings are usually made once a day, but during periods of rapid ground movements, more frequent readings are made. During the period January through August 1976 optical levelling was frequently performed between markers on the four corners of the power house with an accuracy of better than one millimeter.

The power house is located about 1.3 km from the apex of the inflation-deflation bowl and the north-south arm of the tiltmeter is directed almost exactly towards the apex. Hence it is ideally located and oriented to monitor tilt changes caused by elevation changes in the Krafla caldera. An excellent correlation has been found between these two parameters, tilt of the power house and ground elevation inside the Krafla caldera. The tilt can thus be used to monitor daily variations in elevation and volume changes during inflation and deflation events.

Fig. 3 shows the land elevation as derived from levelling and tilt observations in the power house. Uplift or subsidence of the apex of the inflation-deflation area is approximately 3.4 mm for each microradian of tilt at the power house.

Additional dry-tilt stations have been established in the Myvatn-Krafla area, consisting of 5 to 6 bench marks each. Most of these tilt stations are so constructed that the bench marks lie on a circle of 25 m radius and, during measurements, an optical level, Wild N3, is placed exactly in the center of this circle and invar rods are placed on the markers. The relative elevation of the bench marks is established with an accuracy of approximately 0.1 mm, allowing to determine ground tilt of less than 5 microradians. The principal source of error of these tilt measurements is, however, internal deformation of the area covered by each tilt station. A total of 12 such tilt stations are under observation about once every month in the summer, but these measurements are rarely made in the winter due to the snow cover. The arrows in Fig. 7 show observed tilt variations during the inflation period April 29 to September 8, 1977 (Tryggvason, 1978). This correlates well with the levelling measurements. Continuously recording electronic tiltmeters were installed at two locations in late 1977.

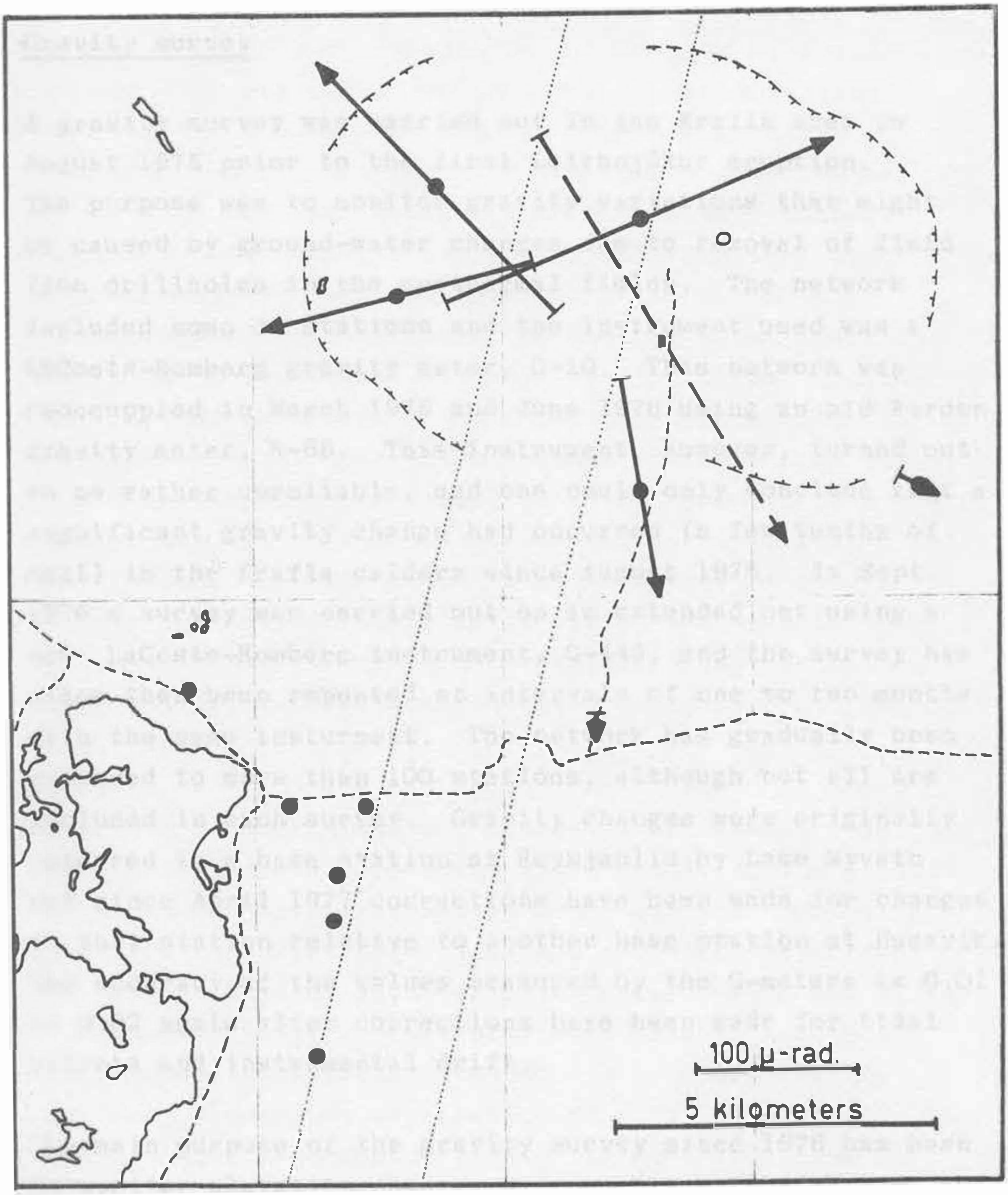

Fig. 7: Observed ground tilt during the inflation period April 29 to September 8, 1977. Solid dots are dry-tilt stations. Arrows show direction and magnitude of observed tilt, and if no arrow is drawn, the tilt was less than the error of the observations. The direction of tilt at the power house (dashed arrow) is based on an electronic tiltmeter which was operated for a few weeks during this period. Dotted lines outline the most active part of the Krafla fissure swarm. For location see Fig. 1 and Fig. 2.

Gravity survey

A gravity survey was carried out in the Krafla area in August 1975 prior to the first Leirhnjúkur eruption. The purpose was to monitor gravity variations that might be caused by ground-water changes due to removal of fluid from drillholes in the goethermal fields. The network included some 30 stations and the instrument used was a LaCoste-Romberg gravity meter, G-10. This network was reoccuppied in March 1976 and June 1976 using an old Worden gravity meter, W-68. This instrument, however, turned out to be rather unreliable, and one could only conclude that a significant gravity change had occurred (a few tenths of mgal) in the Krafla caldera since August 1975. In Sept. 1976 a survey was carried out on an extended net using a new LaCoste-Romberg instrument, G-445, and the survey has since then been repeated at intervals of one to two months with the same insturment. The network has gradually been extended to more than 100 stations, although not all are included in each survey. Gravity changes were originally referred to a base station at Reykjahlid by Lake Myvatn but since April 1977 corrections have been made for changes in that station relative to another base station at Husavik. The accuracy of the values measured by the G-meters is 0.01 to 0.02 mgals after corrections have been made for tidal effects and instrumental drift.

The main purpose of the gravity survey since 1976 has been to monitor elevation changes over a more extensive area than is covered with the level surveys. However, the conversion of gravity changes into elevation changes requires knowledge of changes in mass distribution. As this knowledge is not present, two models have been considered:

1) A free air model, leading to approximately 3 cm elevation change for 0.01 mgal gravity change, and
2) A Bouguer model assuming a density of 2.5 g/cm^3, leading to approximately 5 cm elevation change for 0.01 mgal gravity change.

Repeated gravity measurements have been made at several stations that are regularly included in the levelling survey. Fig. 8 shows the results from one of these stations, FM-5597, located near the Krafla power house, for location see Fig. 5. A comparison is made between measured gravity changes and gravity changes that correspond to measured level changes using the two models. The comparison indicates that the Bouguer model leads to a fairly close agreement with the level changes, although notice should be taken of the additional assumption that no ground movement took place between the levelling survey in 1974 and the gravity survey in 1975. Results from other stations support this conclusion. Since the Bouguer model corresponds to an assumption of no change of density a subsidiary result of the gravity survey has been to lend a support to the theory that the inflation and deflation of the Krafla caldera is accompanied by in- and outflow of magma.

Taking the Bouguer model for granted there remain some noteworthy discrepancies between the levelling and gravity observations. In particular we point out the increasing gap between measured gravity values and those caluclated from levelling after each deflation event during the winter and spring of 1977, and the sharp increase in measured gravity immediately after some of the deflation events (Fig. 8). A possible explanation of both these effects is sinking of the groundwater level. In the first case we may have gradual sinking during the winter months when the ground is covered by snow and in the second case relatively rapid local sinking following an even more abrupt rising during the deflation event. Changes in groundwater pressure to this effect have been observed in drillholes. Expansion of the crustal rocks above the magma chamber, due to e.g. increased steam pressure, would however affect the gravity values in the same way as groundwater sinking. Results from other stations are not detailed enough to provide further insight into these effects.

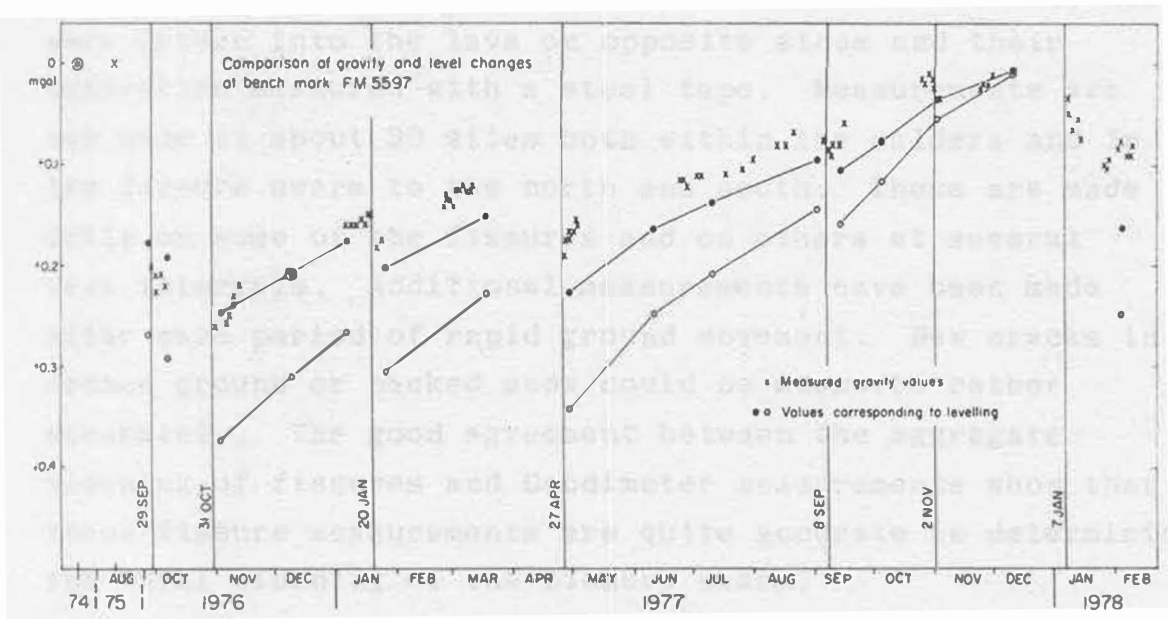

Fig. 8: Comparison of gravity and level changes with time at benchmark FM-5597. For location see Fig. 5. Crosses show measured gravity values. Filled circles show gravity calculated from measured level values assuming the Bouguer model (0.01 mgal ≈ 3 cm). Open circles show gravity values corresponding to measured level values using the free air model (0.01 mgal ≈ 5 cm).

Movements of fissures

Widening of numerous preexisting fissures was observed during the earthquake swarm of December 1975 to February 1976. Due to this, simple fixtures were installed on a number of fissures in the Krafla fissure swarm. This allowed measurements of changes in the width of these fissures by a micrometer with an accuracy of better than 0.1 mm. At some other fissures or swarms of fissures, nails were driven into the lava on opposite sides and their separation measured with a steel tape. Measurements are now made at about 30 sites both within the caldera and in the fissure swarm to the north and south. These are made daily on some of the fissures and on others at several days intervals. Additional measurements have been made after each period of rapid ground movement. New cracks in frozen ground or packed snow could be measured rather accurately. The good agreement between the aggregate widening of fissures and Geodimeter measurements show that these fissure measurements are quite accurate in determining the total widening of the fissure swarm.

Some of the fissures within the caldera show opening during inflation and closing during subsidence, correlating well with the tilt of the power-house as shown in Fig. 9. The fissures in the fissure swarm outside the caldera show no or very little movement except during subsidence events. Then most of the fissures in the center of the active area widen rapidly up to several centimeters. Other fissures on the flanks of the fissure swarm close at the same time. These deformations are mostly permanent.

Continuous recording extensiometers have now been installed at 5 locations but no results are available as yet.

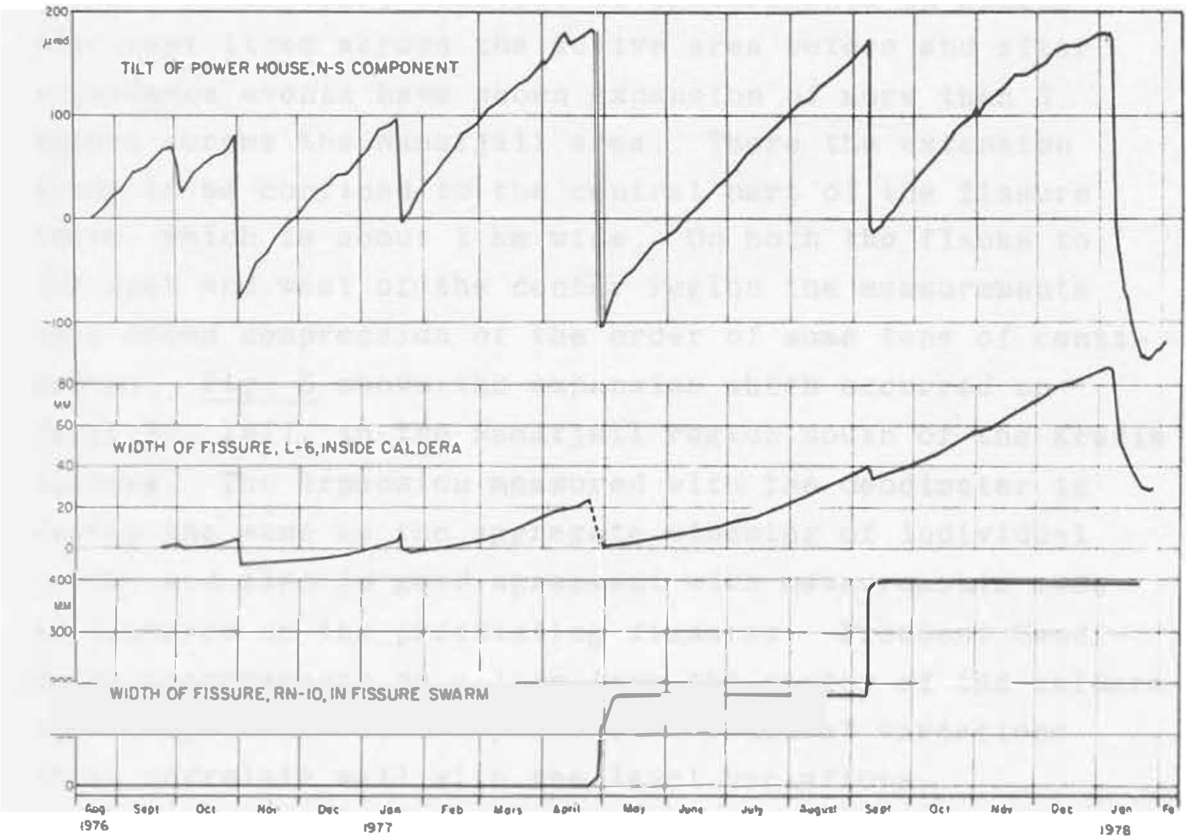

Fig. 9: North-South component of tilt at the Krafla power house from August 1976 to February 1978 and variation in width of fissures, near Leirhnjukur inside the caldera (L-6), and in the fissure swarm by Namafjall about 10 km south of the center of the caldera (RN-10). See Fig. 2 for location.

Distance measurements

An extensive program of Geodimeter measurements was initiated in early 1977 to determine the horizontal component of ground deformation in the Krafla fissure swarm. Preliminary analyses of measurements on single east-west lines across the active area before and after subsidence events have shown expansion of more than 3 meters across the Namafjall area. There the extension seems to be confined to the central part of the fissure swarm, which is about 1 km wide. On both the flanks to the east and west of the center region the measurements have shown compression of the order of some tens of centimeters. Fig. 6 shows the expansion which occurred on April 27, 1977, in the Namafjall region south of the Krafla caldera. The expansion measured with the Geodimeter is nearly the same as the aggregate widening of individual cracks and also in good agreement with measurements made on fixtures on the preexisting fissures. Frequent Geodimeter measurements on a line from the center of the caldera to Namafjall have shown periodic horizontal variations which correlate well with the level variations.

Some other observations

A very dense seismic network has been in operation in the Krafla-Axarfjördur region during the present tectonic episode in North Iceland.

Several other measurements have been made in the area either in order to investigate the high-temperature field or to monitor the tectonic movements presently taking place. They include DC-resistivity soundings, monitoring of ground temperature and ground water level, self-potential measurements, and magnetotelluric-measurements. Temperature, pressure, and chemical composition of borehole discharge is monitored regularly. Gases emitted from fumaroles are analysed and close watch is kept on changes of the geothermal fields.

Some of these observations are important for analysing the horizontal and vertical ground movements. During all major subsidence events an increased pressure or uplift of ground water level has been observed in the deep drillholes both in the Krafla and the Namafjall geothermal fields. At several locations in Gjastykki, the fissure swarm to the north of the caldera, new geothermal fields have been formed and increased activity has been observed in old ones, especially at Namafjall.

INTERPRETATION AND DISCUSSION

The inflation of the Krafla area between subsidence events is interpreted as being caused by inflow of magma from below into a magma chamber at shallow depth beneath the center of the caldera, analogue to conditions at Kilauea, Hawaii (Decker, 1966; Fiske and Kinoshita, 1969, Kinoshita et al, 1974).

Model calcualtions using the simple model of a spherical chamber within an elastic half-space (the Mogi model, Mogi,1958) show good agreement between the calculated and observed ground deformation. Best agreement is obtained if the center of the spherical magma chamber is at a depth of 3 km (Fig. 10). The volume increase of the inflation bulge is close to 5 m^3/sec and this value is taken as the average rate of inflow of magma from below into the Krafla magma chamber. The observations do not show where this magma flow originates.

At the beginning of each inflation period the crust behaves in an elastic manner and no earthquakes are observed. After the uplift has reached a certain critical level, the deformation of the floor of the caldera is no longer purely elastic and earthquakes start occuring. The fissures near the center of the apex of uplift widen in good correlation with the uplift.

The subsidence of the Krafla area is caused by flow of magma out of the magma chamber. This outflow is primarily horizontal and follows the fissure swarm towards north or south, to the region where rifting occurs during each subsidence event (Fig. 4 and 11). The widening of the rift system which allows the flow of magma into the fissures is presumably caused by regional east-west tension which has been built up gradually for one or two centuries due to east-west drift on the constructive plate boundary. The sudden widening of the fissure swarm is accompanied

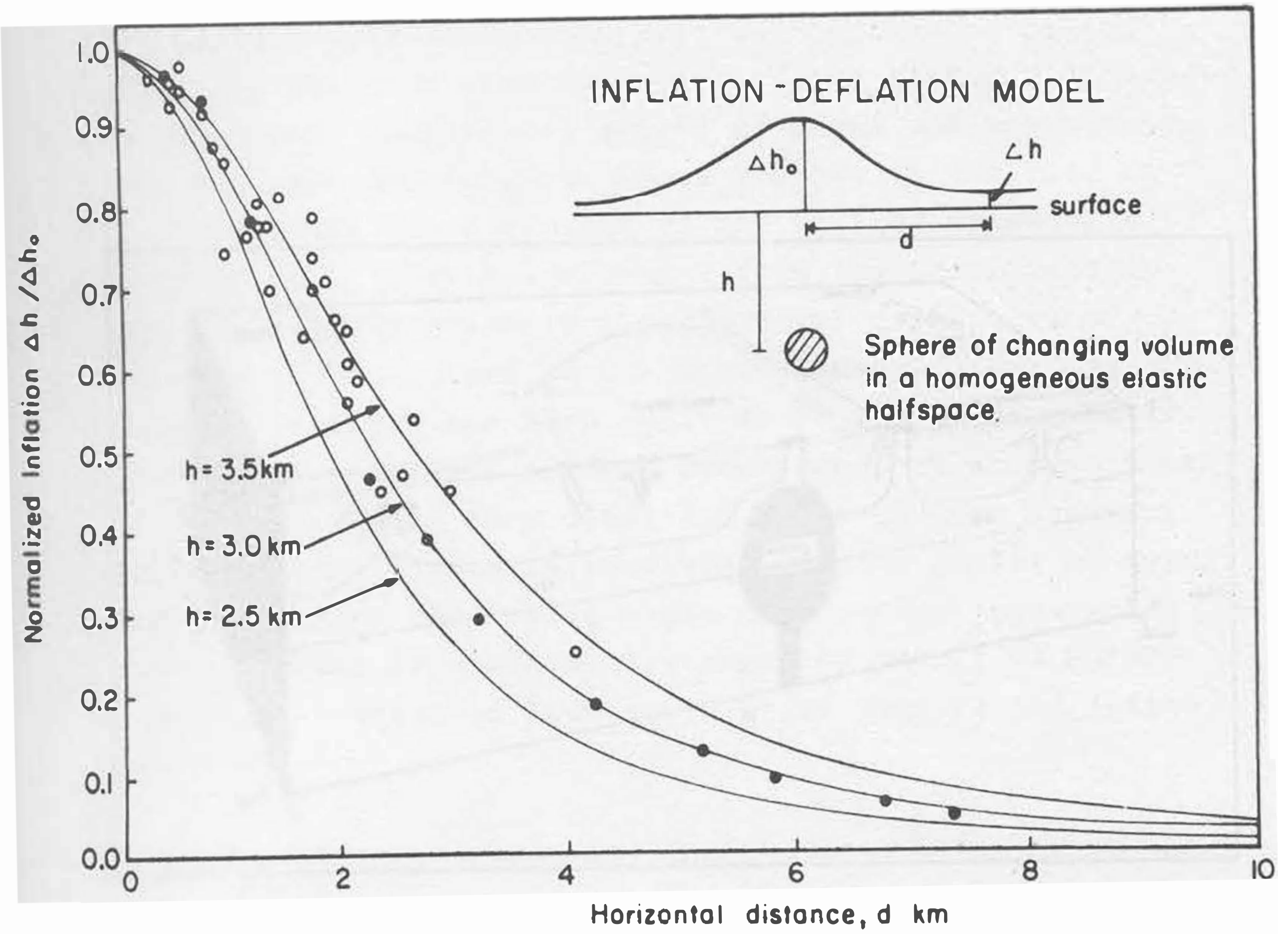

Fig. 10: Inflation-deflation model of the Mogi-type consisting of sphere of changing volume in homogeneous elastic half space, compared with elevation data from the Krafla area. Open circles are data from inside the caldera. Filled circles are measurements on a line from the apex of uplift to the south.

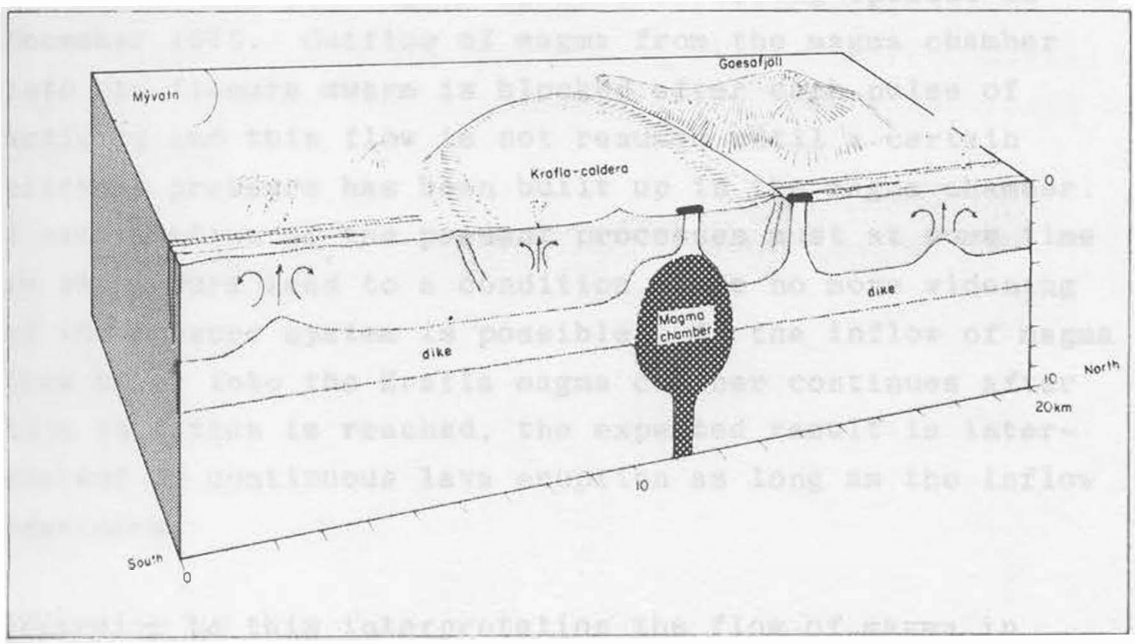

Fig. 11: A block diagram showing schematicly the magma chamber below the Krafla caldera and the dike that has been formed in the present tectonic episode. This dike extends tens of kilometers farther north than indicated. Approximate location of new and intensified steam fields and lava eruptions in 1975 and 1977 are also shown.

by elastic contraction of wide zones on both sides of the fissures (Fig. 6). The pulsation of the rifting episode may be due to limited supply of magma at the beginning of the present episode, so the part of the fissure system which was ready to move could not all be filled with magma in one pulse. Additional supply of magma was needed and this has been entering the magma chamber at the rate of 5 m^3/sec since the beginning of the rifting episode in December 1975. Outflow of magma from the magma chamber into the fissure swarm is blocked after each pulse of activity and this flow is not resumed until a certain critical pressure has been built up in the magma chamber. A continuation of the present processes must at some time in the future lead to a condition where no more widening of the fissure system is possible. If the inflow of magma from below into the Krafla magma chamber continues after this condition is reached, the expected result is intermittent or continuous lava eruption as long as the inflow continues.

According to this interpretation the flow of magma in the crust is a secondary phenomena and the regional plate movement the primary factor. On the other hand it seems clear that when rifting occurs it starts where the mechanical strength of the crust is lowest. In the Krafla area this place is within the caldera where the magma chamber is located. Thus we can look at the caldera and the magma chamber as a trigger for the episodical drift-movements on the plate boundary in northern Iceland.

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