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ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, recommending three 45-minute class periods; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Using four types of data recorded by geologists, students determine the position of the mid-Atlantic ridge as it crosses Iceland, the only extensive area of plate growth lying above water. In addition to examining types of geological activity in Iceland related to plate growth and fitting data consistent with a single explanation, benefits and hazards to Iceland's citizens resulting from being on the mid-Atlantic ridge are examined. (Author/JN)

CCEP™

CRUSTAL EVOLUTION EDUCATION PROJECT

Iceland: The Case Of The Splitting Personality

TEACHER'S GUIDE

Catalog No. 34W1014

For use with Student Investigation 34W1114
Class time: three 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition history and processes of the earth s crust and the application of this knowledge to man s activities The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers CEEP materials have been developed by teams of science educators classroom teachers and scientists Prior to publication the materials were field tested by more than 200 teachers and over 12 000 students

Current crustal evolution research is a breaking story that students are living through today Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading continental drift and plate tectonics

We know that you will enjoy using CEEP modules in your classroom Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules

About CEEP Modules...

Most CEEP modules consist of two booklets a Teacher s Guide and a Student Investigation The Teacher s Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color intended only for the teacher as well as answers to the questions that are included in the Student Investigation In some modules there are illustrations that appear only in the Teacher s Guide and these are designated by figure letters instead of the number sequence used in the Student Investigation

For some modules maps rulers and other common classroom materials are needed and in varying quantities according to the method of presentation Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module

Each module is individual and self-contained in content but some are divided into two or more parts for convenience The recommended length of time for each module is indicated Some modules require prerequisite knowledge of some aspects of basic earth science this is noted in the Teacher s Guide

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Iceland: The Case Of The Splitting Personality

INTRODUCTION

In this investigation, students determine the position of the Mid-Atlantic Ridge as it crosses Iceland, using four types of data recorded by geologists studying the country. They also learn about the various effects of geological activity on the residents of Iceland.

Iceland is unique. It is the only sizable land area that sits astride a mid-ocean ridge. This has important and, at times, disastrous effects on its citizens. It has a great deal of **geological activity** (earthquakes and volcanism). Volcanoes may erupt without warning. Lava may pour out of cracks in the surface. In 1970, ash containing a fluoride mineral erupted from the volcano Hekla. The fluoride contaminated nearby grasslands on which sheep grazed, over 7000 died from fluoride poisoning.

On the other hand, the capital city of Reykjavik gets all of its energy for heating from **geothermal sources.** This geothermal energy comes from ground water that is heated by the hot rock inside the earth and then pumped to the surface. In fact, Iceland has so much geothermal energy that officials are thinking of exporting it to energy-hungry countries such as the United States.

These phenomena and others are the result of Iceland's position on the Mid-Atlantic Ridge. Scientists are interested in this country because here they can study the mechanisms of plate growth. This information can add to an understanding of crustal evolution. In this module you will work with four different types of data that relate to plate growth. They represent actual data accumulated and studied by scientists.

PREREQUISITE STUDENT BACKGROUND

Students should be familiar with the basic concepts of plate tectonics, earthquakes, volcanic activity, paleomagnetism and geothermal activity. They should also know how to use longitude and latitude to locate places on the earth.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Identify the types of geological activity in Iceland related to plate growth.
2. Fit together several types of data on geological activity so that they are consistent with a single explanation.
3. Identify the benefits and hazards to the citizens of Iceland that result from being on the Mid-Atlantic Ridge.

MATERIALS

For each pair of students:

- **Map of Iceland**
- **Marking pencils**
- **Ruler**

For the class:

- **Set of three overhead transparencies—one transparency for each type of data plotted on a map of Iceland. Use a different color of marking pencil for each type of data.**
- **Map of the ocean floors, especially the North Atlantic.**

BACKGROUND INFORMATION

Icelahd is of great interest to geologists since it is the only extensive area of plate growth that lies above water. This provides an ideal platform for studying the volcanic activity involved in plate growth and the related magnetic anomaly patterns and earthquake activity.

There is a problem, however. Why is Iceland above sea level when all other portions of the mid-ocean ridge system, except for isolated volcanic islands, lie below sea level? This implies that somehow Iceland is different. If so, the mechanisms of plate growth in Iceland might be different from elsewhere along the mid-ocean ridges. Several characteristics illustrate these differences. The rift in Iceland splits in two in the southern part of the country. This is highly unusual. Even more unusual, however, is the fact that up to 15 percent of the lava extruded at the surface is acidic or rhyolitic in composition. The ocean floor is made up of basic, or basaltic, rock.

A line of volcanoes, including Hekla, begins eruptions by throwing out rhyolitic lava. As the eruption continues, the lava becomes less and less acidic until finally lava of basaltic composition is being erupted. Rhyolitic material is thought to be typical of continental growth. Is Iceland a growing continent? This is just one of the many interesting questions raised in the study of Iceland.

SUGGESTED APPROACH

This should be conducted as a total class activity with pre-lab discussion, lab, and post-lab discussions.

Discuss with your students the OBJECTIVES and the INTRODUCTION during pre-lab.

Explain data-plotting procedures and the symbols to be used on the worksheets for each type of data. This information is included on each data sheet. Assign each part under PROCEDURE to a different group. This will reduce the amount of time necessary to conduct the module. You should assign students to groups according to how fast they work. PART A of the module has the fewest points to be plotted, so it should be assigned to the slowest students. PART B has the greatest number of locations, and it should be assigned to the fastest students. Each pair of students within a group should be given a copy of the appropriate Student Investigation (PART A, B or C) and Worksheet 1 (the outline map of Iceland). One student can read the locations to the other student who then plots them on the map. After plotting all the locations, the students should write out the answers to the questions.

While the groups are working during the laboratory, circulate to be certain that they are plotting the data correctly. On the basis of the data they plot in this module, students are asked to locate the Mid-Atlantic Ridge where it crosses Iceland. Scientists themselves disagree on the exact location. However, they do agree that it is located in the active zone shown in Figure A. Therefore, you should accept any solution a student suggests, provided it falls within the active zone and fits the data the student has plotted.

Those students who worked on the same type of data should compare their plots during the post-lab and resolve any discrepancies. Discuss each of the questions asked on the data sheets. Following this discussion select one representative map from each of the three data groups (A, B and C) and plot the data on an overhead transparency of the map of Iceland. An alternative is to assign one pair of students from each group (A, B and C) to plot their data on a transparency of Worksheet 1. The three transparencies can then be used in a post-lab discussion. Superimpose them using an overhead projector. Use the SUMMARY QUESTIONS to lead a final class discussion.

PROCEDURE

PART A What is the magnetic anomaly across Iceland?

By plotting positive anomalies on an outline map of Iceland, students learn about sea-floor spreading and the Mid-Atlantic Ridge.

Key words: geological activity, geothermal sources, positive anomalies

Time required: one 45-minute period

Materials. Worksheet 1, ruler and colored pencils.

1. Plot each location of positive anomalies listed in Table 1 on the map of Iceland (Worksheet 1). A positive anomaly indicates a time of normal magnetic polarity. Use a + sign.

Latitude N	*Longitude W*
63° 50′	22° 30′
63° 50′	22° 00′
63° 50′	21° 30′
64° 10′	21° 00′
64° 20′	20° 30′
64° 30′	20° 30′
64° 40′	20° 00′
64° 50′	23° 30′
64° 50′	23° 00′
64° 50′	22° 30′
63° 20′	20° 30′
63° 30′	19° 30′
64° 00′	19° 00′
64° 20′	18° 30′
64° 30′	17° 30′
64° 50′	17° 00′
65° 00′	17° 00′
65° 20′	16° 30′
65° 30′	16° 30′
65° 50′	16° 30′
66° 10′	16° 30′

Table 1 Locations of high positive anomalies

High positive anomalies should fall within the active zone in Figure A.

When molten rock is intruded into rocks near the earth's surface and hardens, it acquires the same magnetic field as the earth. The induced field supplements or reinforces the earth's field. Magnetic surveys will thus reveal a higher-than-expected value for these induced fields.

When older rocks were formed during certain periods in the past, the earth's magnetic field was reversed from today's field, and the magnetic field of these rocks was also reversed. Therefore, magnetic surveys will find a lower-than-expected reading for these areas. The higher readings indicate positive anomalies and the lower readings indicate negative anomalies. Usually along an oceanic rift zone, such as that going through Iceland, positive and negative anomalies will alternate, forming magnetic anomaly patterns. The magnetic fields get weaker as the distance from the rift increases. This is because the magnetized minerals in the rocks become altered chemically by the action of water. The altered minerals are not as highly magnetic as the unaltered ones and do not have as great an effect on the earth's magnetic field.

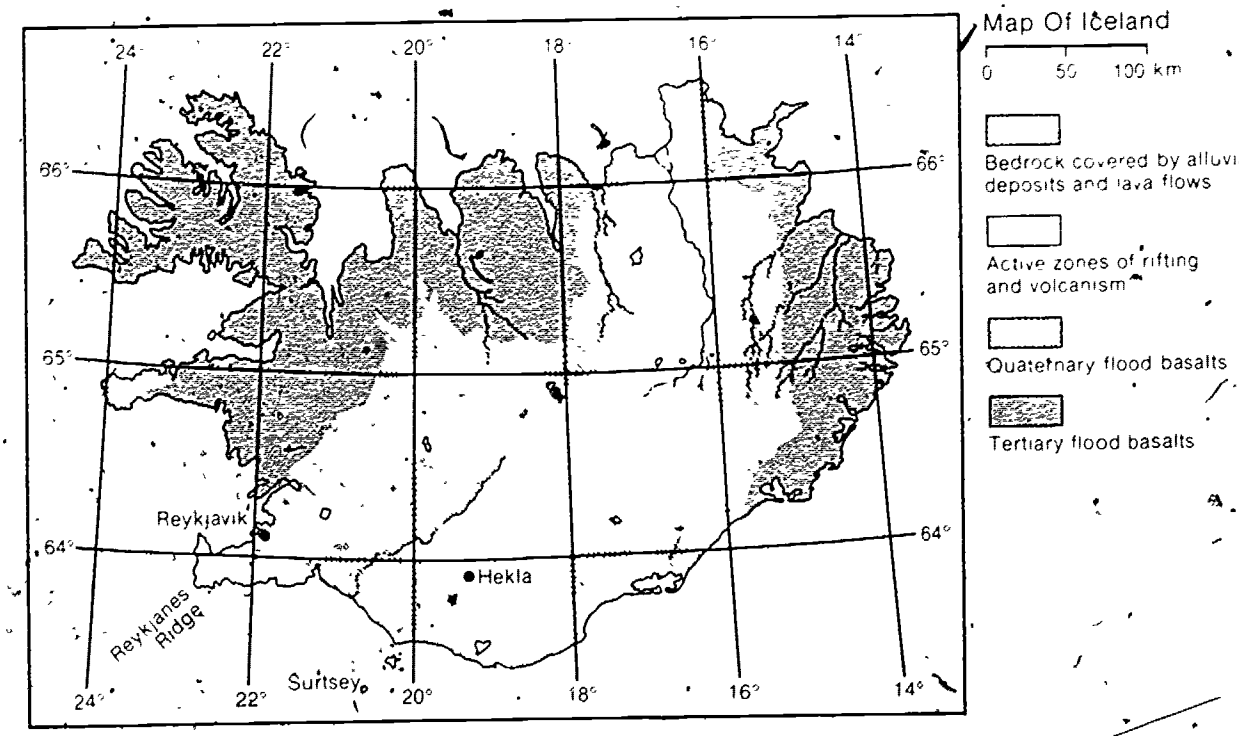

Figure A. The major geological elements of Iceland and the distribution of high temperature geothermal activity. Modified from K. Saemundsson, 1974, *Geodynamics of Iceland and the North Atlantic Area.*

2. Describe the anomaly pattern across Iceland

It will fall within the active zone in Figure A. (See Answer Sheet 1.) There appear to be three separate zones, one of which goes completely across Iceland from south to north.

3. Shade in a zone on the map where you think the Mid-Atlantic Ridge crosses Iceland

The ridge should be in the active zone in Figure A.

4. Can you tell if Iceland is spreading apart? Explain

Students cannot tell from this information alone.

Magnetic anomalies are highly complex phenomena. The highest positive anomalies are recent, and they indicate that new crust has been forming in these zones. The data provided here are incomplete. Only data on the highest positive anomalies are given. Zones of negative anomalies parallel the positive zones. In addition, zones of weaker positive anomalies occur farther away from the rift. These have been left out to simplify the plotting and interpretation by the students. As students raise questions while plotting anomaly data, you should tell them about this other data. It should also be brought out in the post-lab discussion.

Display a map of the ocean floors. The students will then be able to see the relationship between the Mid-Atlantic Ridge and Iceland.

PROCEDURE

PART B What are the ages of volcanic rock in Iceland and where do geothermal areas occur?

Students learn the relationship between volcanic and geothermal activity and the spreading of Iceland that is taking place along the Mid-Atlantic Ridge.

Key words: none

Time required: one 45-minute period

Materials Worksheet 2, ruler and colored pencils.

1. Plot each location of volcanic rock in Table 2 on Worksheet 2. Use a check mark (✓) for locations of Recent volcanic activity (10,000 years ago to present), a zero (0) for locations of Pleistocene activity (one million years ago) and an "X" for those of the earlier activity in the Tertiary (13 million years ago)

Recent (✓)

Latitude N	*Longitude W*
63°50′	19°00′
64°00′	19°30′
64°10′	17°00′
65°00′	16°30′
65°40′	17°00′
64°50′	23°30′

Pleistocene (0)

Latitude N	*Longitude W*
63°40′	19°30′
64°10′	20°00′
64°30′	19°00′
64°20′	17°30′
65°50′	18°00′
65°50′	15°30′
64°10′	21°00′
64°50′	23°00′
65°00′	23°00′
64°50′	22°30′
65°00′	22°30′

Tertiary (X)

Latitude N	*Longitude W.*
64°20′	21°30′
64°30′	22°00′
64°40′	21°00′
64°50′	22°00′
64°50′	21°30′
65°20′	21°30′
65°30′	22°00′
66°00′	21°30′
65°40′	23°30′
66°20′	22°30′
65°30′	20°30′
65°40′	19°30′
66°10′	18°00′
65°30′	18°00′
65°20′	18°30′
65°40′	14°30′
65°30′	13°30′
65°10′	13°30′
65°00′	14°00′
65°00′	14°30′
64°50′	14°30′
64°30′	14°30′
64°30′	15°00′
64°20′	15°30′
64°20′	16°00′

Table 2 Locations and ages of volcanic rock

2. Describe the pattern formed by the plot of the ages of volcanic rock on Iceland.

See Figure A and Answer Sheet 2.

3. Using a different color than that used for plotting the volcanic data, plot each of the locations of geothermal activity listed in Table 3 on Worksheet 2, using a small "w".

Latitude N	*Longitude W*
66° 10′	16° 30′
65° 50′	17° 00′
65° 20′	16° 30′
64° 40′	16° 30′
64° 30′	17° 30′
64° 40′	18° 00′
63° 40′	19° 00′
64° 00′	19° 30′
64° 00′	21° 30′
64° 30′	19° 30′
64° 50′	19° 30′
64° 20′	20° 30′
63° 50	22° 00′

Table 3 Locations of geothermal activity

4. Describe the pattern formed by the plot of geothermal locations in Iceland

The high temperature areas are marked in Figure A and Answer Sheet 2.

5. Shade in a zone on the map where you think the Mid-Atlantic Ridge crosses Iceland.

The ridge should be in the active zone in Figure A. See Answer Sheet 2.

6. Is Iceland spreading apart? Yes Can you tell from the data that you have? Yes

Since volcanic rock occurs in bands that become progressively older moving away from the rift zone, this implies that Iceland is spreading apart. An alternative explanation of these ages, however, involves three periods of volcanic activity. The oldest rock could represent a period of extensive volcanism that occurred throughout Iceland. This could have been succeeded by a less extensive volcanism period. The lava that erupted during this second period could have covered only a part of the older material. The latest and least extensive period of volcanism would be represented by rock that covered only the narrow zone on each side of the rift. Such a sequence has not been observed on as large a scale as the area of Iceland and therefore geologists think that it is an unlikely explanation for the pattern of volcanic deposits observed in Iceland.

The preferable explanation, especially in view of the general acceptance of the theory of plate tectonics, is that Iceland is splitting apart and that the older rock was formed a long time ago at the rift zone. This continuing process accounts for the successively older age of rock going away from the rift on either side.

7. If you were planning to construct a factory in Iceland that required huge quantities of energy, where would you locate it? Why?

The factory should be built near geothermal areas where hot water is available to supply its energy needs.

During the post-lab you should point out that the occurrence of earthquakes must also be considered. Some geothermal areas are relatively earthquake-free and logical sites for a factory, provided transportation and other necessities are available.

PROCEDURE

PART C. Where do earthquakes occur in Iceland?

Students learn how earthquakes are related to the spreading of Iceland and the Mid-Atlantic Ridge.

Key words: none

Time required: one 45-minute period

Materials. Worksheet 3, ruler and colored pencils.

1. Plot the locations of the earthquakes indicated in Table 4 on Worksheet 3. Use the symbol indicated on the Table. Place one symbol for each earthquake For example, at 66°40'N , 17°30'W., you should place three of the number 4.

MAGNITUDES = 4-5 (1956-1962)
Symbol = 4

Latitude N	*Longitude W*	*Number*
66°50′	18°30′	1
66°40′	18°30′	1
66°40′	17°30′	3
66°30′	17°30′	2
66°30′	18°30′	1
66°20′	18°30′	2
66°10′	17°30′	1
65°00′	16°30′	4
64°50′	17°30′	2
64°50′	17°00′	1
64°40′	17°00′	1
64°30′	17°00′	1
64°20′	17°30′	2
63°50′	19°00′	2
63°40′	19°00′	8
63°40′	23°30′	1
63°50′	22°00′	4
64°30′	20°30′	1
64°40′	20°30′	1

5 ≥ MAGNITUDE ≤ 6 (since 1910)
Symbol = 5

Latitude N	*Longitude W*	*Number*
63°30′	24°00′	2
63°30′	23°30′	7
63°20′	23°30′	6
63°50′	22°30′	1
63°50′	22°00′	2
63°50′	21°30′	3
64°00′	20°30′	1
64°00′	19°30′	2
64°30′	20°30′	4
66°00′	17°30′	2
66°30′	19°30′	1
66°30′	18°00′	1
66°30′	17°30′	2
66°40′	17°30′	1
66°50′	17°30′	2

6 ≥ MAGNITUDE ≤ 7 (since 1910)
Symbol = 6

Latitude N	*Longitude W*	*Number*
63°50′	22°30′	1
63°50′	21°30′	1
64°00′	21°30′	1
64°10′	20°00′	1
66°00′	18°30′	1

MAGNITUDE = 7 (since 1910)
Symbol = 7

Latitude N	*Longitude W*	*Number*
64°00′	20°00′	1
66°20′	19°30′	1

Table 4 Locations and magnitudes of earthquakes.

2. Describe the pattern formed by the intensity and number of earthquakes as they have occurred across Iceland

Students should be able to identify two zones or one that branches to the south. See Answer Sheet 3.

3. Where do you think the Mid-Atlantic Ridge crosses Iceland? Shade in a zone on your map to indicate the ridge.

The ridge should be in the active zone in Figure A.

4. Can you tell if Iceland is spreading apart? Explain.

Your students will not be able to tell if Iceland is spreading apart from the earthquake data alone. Actually, seismologists have developed a method to determine, during an earthquake, the relative movement of rock masses on either side of a fault. By applying these complex methods of data collection and interpretation to current earthquake activity, they can tell that Iceland is spreading apart.

5. If you were building a house in Iceland, what areas would you avoid? Why?

Earthquakes typically occur along mid-ocean rifts either in a zone about 10 km below the surface or in a zone about 70 km below the surface.

The data your students plot does not distinguish between these two zones of earthquake activity. The shallower earthquakes are more destructive. They are more likely to occur in the vicinity of the rift zone and in areas of active volcanism. Unfortunately, these are also areas of the greatest amount of geothermal activity. Care must be taken in placing settlements to take advantage of the energy supplied by geothermal areas so that they are reasonably safe from earthquake and volcanic activities.

You may want to discuss these ideas with students while they are plotting the earthquake data. These ideas should also be brought out in the post-lab discussion.

SUMMARY QUESTIONS

1. Several different kinds of data have been used in this investigation. Which types seem to be most useful in determining the location of the ridge?

Each type of data is important in providing a well-documented picture of Iceland in relation to the ridge. Each set of data supports the other. Students should see how their data help to confirm the presence of the ridge in Iceland.

2. What types of geological activity would you expect to occur along the Mid-Atlantic Ridge south and north of Iceland?

The same types of geological activity will occur elsewhere along the ridge. You might want to use maps of earthquakes and volcanic activity in the Atlantic Ocean to point this out. This would be a good lead into a discussion of sea-floor spreading.

3. Volcanic rock on Iceland in general becomes older the farther it is from the active zones. Volcanoes located on the west coast are an exception How can their young age be explained?

A hot spot occurs where molten rock related to a ridge system finds a weak point in the crust, not necessarily on the ridge. The molten rock then comes up through the weak spot instead of the ridge. See article by Vogt.

4. What is the source of the hot water that provides much of the energy used in Iceland?

As magma below Iceland cools, it releases very hot water. In addition, ground water circulating through areas of volcanic activity will be heated by the warm rock it passes through. See article by Weaver.

5. What geologic hazards result from Iceland's position on the ridge?

Earthquakes and volcanic activity are the most notable. Their effects upon the population should be discussed. See article by Grove.

Another hazard that may be of interest to your students, not mentioned in the activity, is the occurrence of jökulhlaup (glacier burst). These are tremendous floods of water from under the glaciers. They result from the melting of glacial ice due to volcanic activity occurring below the ice. As melting from the volcanic activity proceeds, the water below the glacier rises. Eventually, the glacier will float above the rock rim enclosing it. When this happens, the water suddenly will gush out into the surrounding countryside, carrying large and small chunks of rock with it. Vast aprons of this debris are found in several places in Iceland. A single burst may contain over 6 cubic kilometers of water, and often result in a discharge of water greater than that of the Amazon River. They do great damage to farms and have claimed many lives.

6. Where would you locate an expensive factory that required great quantities of heat energy?

Using the transparencies of earthquakes and volcanic and geothermal activity, locate the geothermal areas that do not coincide with earthquake and volcanic areas.

HELPFUL BACKGROUND MATERIAL FOR CLASSROOM PRESENTATION

Sound filmstrips

Iceland: a volcano erupts, with cassette or record. Prentice-Hall Media, Tarrytown, NY.

Iceland: geologic activity, with cassette or record. Prentice-Hall Media, Tarrytown, NY.

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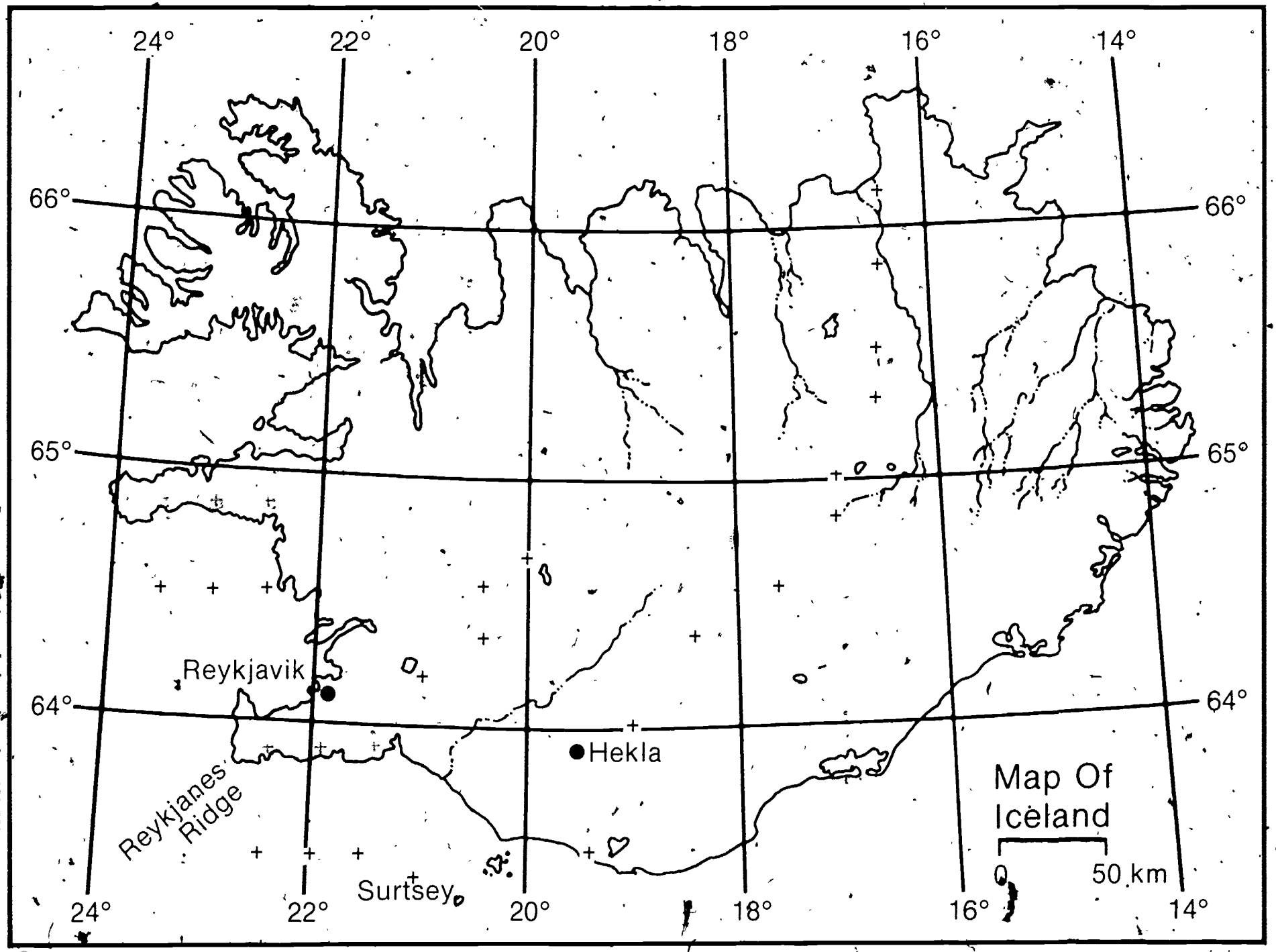
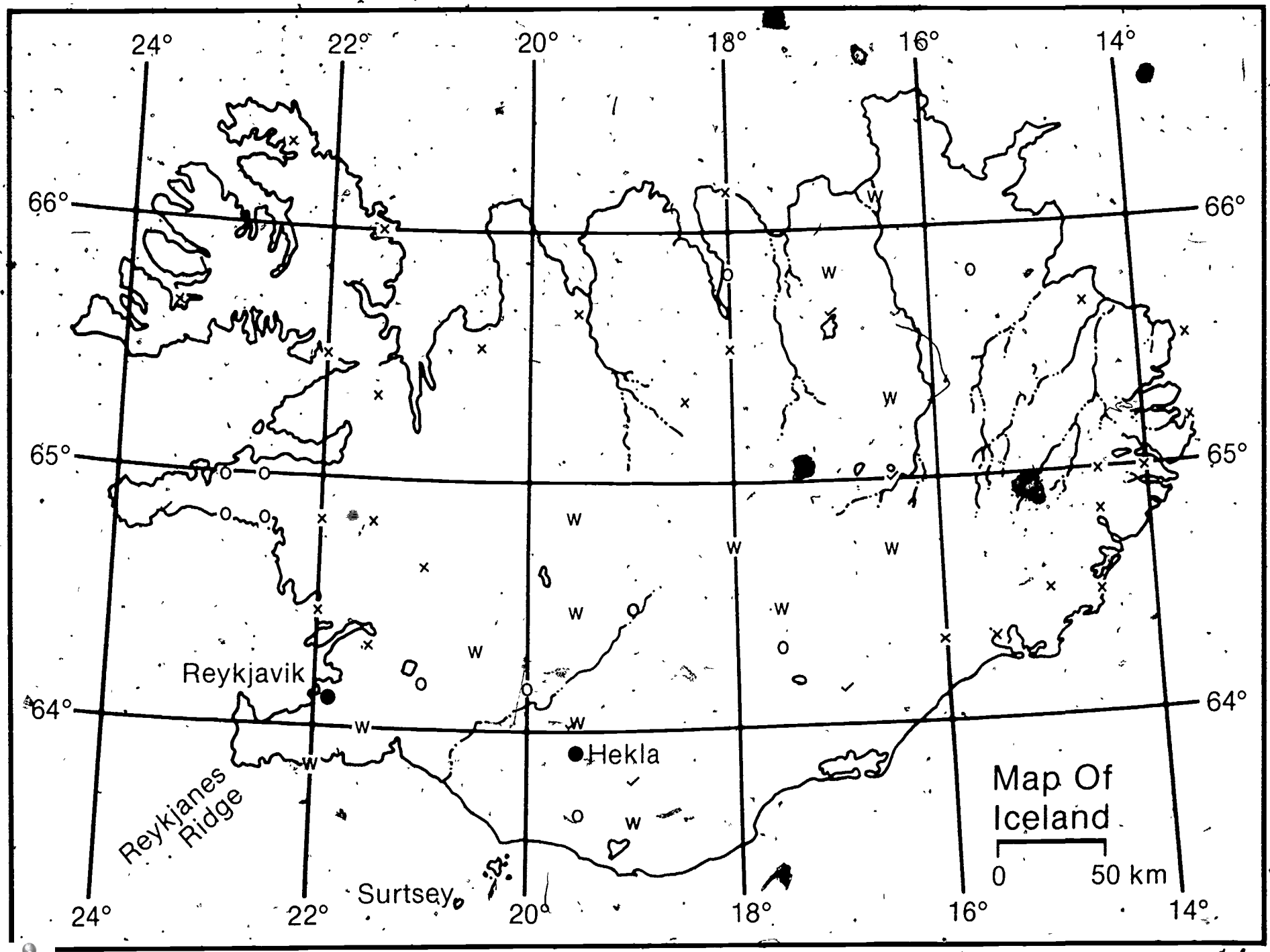
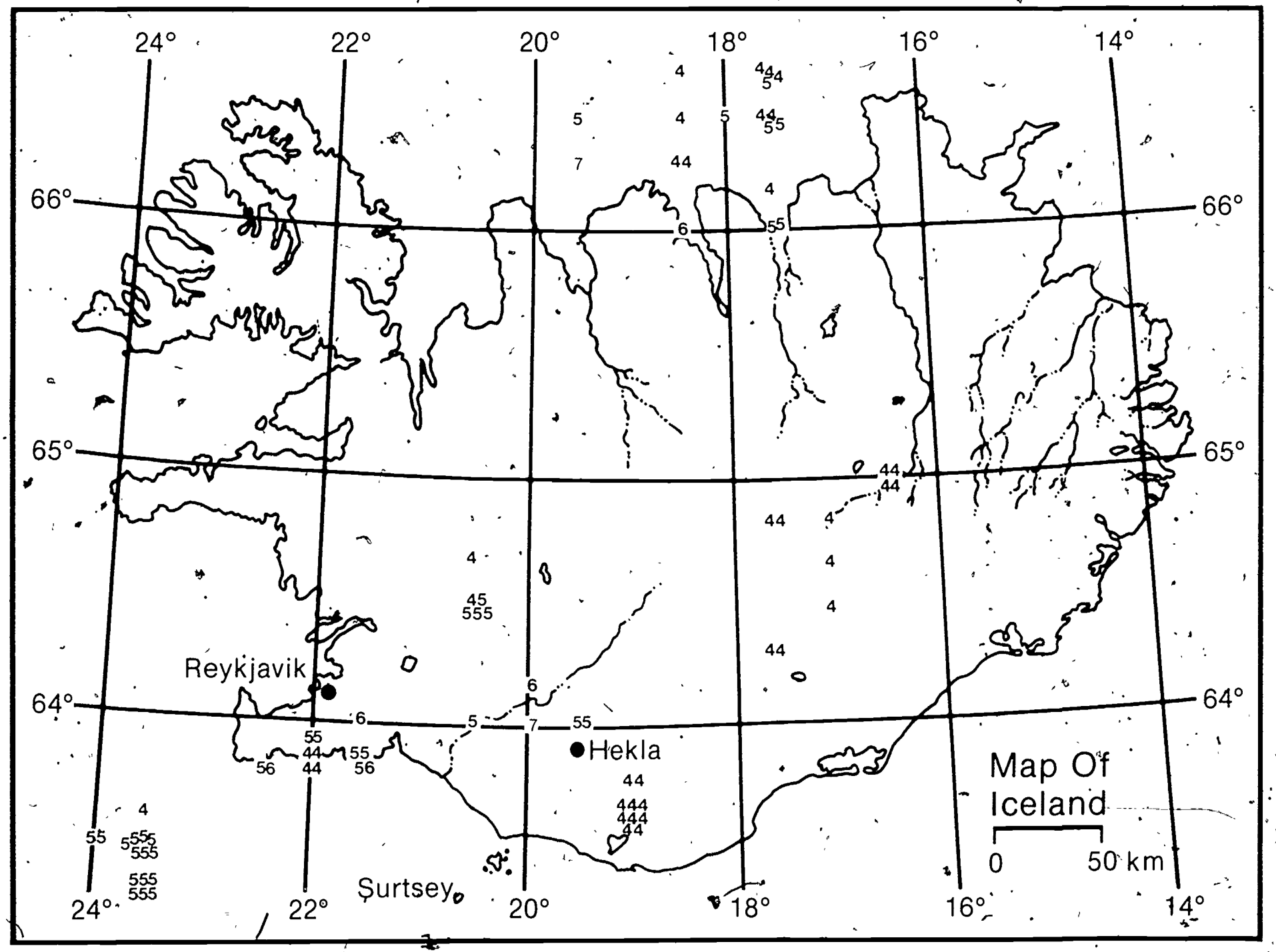


Note: Error in location of the plots for 63° 50' and 64° 50'. Correct plots are marked in red.

wer Sheet 1 (PART A)


24°
22°
20°
18°
16°
14°
66°
65°
64°
Reykjavik
Hekla
Surtsey
Reykjanes Ridge
Map Of Iceland
0
50 km



Answer Sheet 3 (PART C)

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	2	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3	34 W 1202
• Crustal Movement: A Major Force In Evolution	2	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	2	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	1	34 W 1207
• Fossils As Clues To Ancient Continents	2	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	1	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	1	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	1	34 W 1212
• How Fast Is The Ocean Floor Moving?	2	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	1	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	1	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	1	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
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CRUSTAL EVOLUTION EDUCATION PROJECT

NAME

DATE

Student Investigation

Catalog No 34W1114

Iceland: The Case Of The Splitting Personality

INTRODUCTION

Iceland is unique. It is the only sizable land area that sits astride a mid-ocean ridge. This has important and, at times, disastrous effects on its citizens. It has a great deal of **geological activity** (earthquakes and volcanism). Volcanoes may erupt without warning. Lava may pour out of cracks in the surface. In 1970, ash containing a fluoride mineral erupted from the volcano Hekla. The fluoride contaminated nearby grasslands on which sheep grazed, over 7000 died from fluoride poisoning.

On the other hand, the capital city of Reykjavik gets all of its energy for heating from **geothermal sources.** This geothermal energy comes from ground water that is heated by the hot rock inside the earth and then pumped to the surface. In fact, Iceland has so much geothermal energy that officials are thinking of exporting it to energy-hungry countries such as the United States.

These phenomena and others are the result of Iceland's position on the Mid-Atlantic Ridge. Scientists are interested in this country because here they can study the mechanisms of plate growth. This information can add to an understanding of crustal evolution. In this module you will work with four different types of data that relate to plate growth. They represent actual data accumulated and studied by scientists.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Identify the types of geological activity in Iceland related to plate growth.
2. Fit together several types of data on geological activity so that they are consistent with a single explanation.
3. Identify the benefits and hazards to the citizens of Iceland that result from being on the Mid-Atlantic Ridge.

PROCEDURE

PART A. What is the magnetic anomaly across Iceland?

Materials: Worksheet 1, ruler and colored pencils.

1. Plot each location of positive anomalies listed in Table 1 on the map of Iceland (Worksheet 1). A positive anomaly indicates a time of normal magnetic polarity. Use a + sign.

Latitude N	*Longitude W*
63°50′	22°30′
63°50′	22°00′
63°50′	21°30′
64°10′	21°00′
64°20′	20°30′
64°30′	20°30′
64°40′	20°00′
64°50′	23°30′
64°50′	23°00′
64°50′	22°30′
63°20′	20°30′
63°30′	19°30′
64°00′	19°00′
64°20′	18°30′
64°30′	17°30′
64°50′	17°00′
65°00′	17°00′
65°20′	16°30′
65°30′	16°30′
65°50′	16°30′
66°10′	16°30′

Table 1. Locations of high positive anomalies.

2. Describe the anomaly pattern across Iceland.

3. Shade in a zone on the map where you think the Mid-Atlantic Ridge crosses Iceland.

4. Can you tell if Iceland is spreading apart? Explain.

PROCEDURE

PART B: What are the ages of volcanic rock in Iceland and where do geothermal areas occur?

Materials: Worksheet 2, ruler and colored pencils.

1. Plot each location of volcanic rock in Table 2 on Worksheet 2. Use a check mark (✓) for locations of Recent volcanic activity (10,000 years ago to present), a zero (0) for locations of Pleistocene activity (one million years ago) and an "X" for those of the earlier activity in the Tertiary (13 million years ago).

Recent (✓)

Latitude N	*Longitude W*
63°50′	19°00′
64°00′	19°30′
64°10′	17°00′
65°00′	16°30′
65°40′	17°00′
64°50′	23°30′

Pleistocene (0)

Latitude N	*Longitude W*
63°40′	19°30′
64°10′	20°00′
64°30′	19°00′
64°20′	17°30′
65°50′	18°00′
65°50′	15°30′
64°10′	21°00′
64°50′	23°00′
65°00′	23°00′
64°50′	22°30′
65°00′	22°30′

Tertiary (X)	
Latitude N	*Longitude W*
64°20′	21°30′
64°30′	22°00′
64°40′	21°00′
64°50′	22°00′
64°50′	21°30′
65°20′	21°30′
65°30′	22°00′
66°00′	21°30′
65°40′	23°30′
66°20′	22°30″
65°30′	20°30′
65°40′	19°30′
66°10′	18°00′
65°30′	18°00′
65°20′	18°30′
65°40′	14°30′
65°30′	13°30′
65°10′	13°30′
65°00′	14°00′
65°00′	14°30′
64°50′	14°30′
64°30′	14°30′
64°30′	15°00′
64°20′	15°30′
64°20′	16°00′

Table 2 Locations and ages of volcanic rock.

2. Describe the pattern formed by the plot of the ages of volcanic rock on Iceland.

3. Using a different color than that used for plotting the volcanic data, plot each of the locations of geothermal activity listed in Table 3 on Worksheet 2, using a small "w".

Latitude N	*Longitude W*
66°10′	16°30′
65°50′	17°00′
65°20′	16°30′
64°40′	16°30′
64°30′	17°30′
64°40′	18°00′
63°40′	19°00′
64°00′	19°30′
64°00′	21°30′
64°30′	19°30′
64°50′	19°30′
64°20′	20°30′
63°50′	22°00′

Table 3. Locations of geothermal activity.

4. Describe the pattern formed by the plot of geothermal locations in Iceland.

5. Shade in a zone on the map where you think the Mid-Atlantic Ridge crosses Iceland.

6. Is Iceland spreading apart? _____ Can you tell from the data that you have? _____

7. If you were planning to construct a factory in Iceland that required huge quantities of energy, where would you locate it? Why?

PROCEDURE

PART C: Where do earthquakes occur in Iceland?

Materials: Worksheet 3, ruler and colored pencils.

1. Plot the locations of the earthquakes indicated in Table 4 on Worksheet 3. Use the symbol indicated on the Table. Place one symbol for each earthquake. For example, at 66°40'N., 17°30'W., you should place three of the number 4.

MAGNITUDES = 4–5 (1956–1962)
Symbol = 4

Latitude N	*Longitude W*	*Number*
66°50′	18°30′	1
66°40′	18°30′	1
66°40′	17°30′	3
66°30′	17°30′	2
66°30′	18°30′	1
66°20′	18°30′	2
66°10′	17°30′	1
65°00′	16°30′	4
64°50′	17°30′	2
64°50′	17°00′	1
64°40′	17°00′	1
64°30′	17°00′	1
64°20′	17°30′	2
63°50′	19°00′	2
63°40′	19°00′	8
63°40′	23°30′	1
63°50′	22°00′	4
64°30′	20°30′	1
64°40′	20°30′	1

5 ≥ MAGNITUDE ≤ 6 (since 1910)
Symbol = 5

Latitude N	*Longitude W*	*Number*
63°30′	24°00′	2
63°30′	23°30′	7
63°20′	23°30′	6
63°50′	22°30′	1
63°50′	22°00′	2
63°50′	21°30′	3
64°00′	20°30′	1
64°00′	19°30′	2
64°30′	20°30′	4
66°00′	17°30′	2
66°30′	19°30′	1
66°30′	18°00′	1
66°30′	17°30′	2
66°40′	17°30′	1
66°50′	17°30′	2

6 ≥ MAGNITUDE ≤ 7 (since 1910)
Symbol = 6

Latitude N	*Longitude W*	*Number*
63°50′	22°30′	1
63°50′	21°30′	1
64°00′	21°30′	1
64°10′	20°00′	1
66°00′	18°30′	1

MAGNITUDE = 7 (since 1910)
Symbol = 7

Latitude N	*Longitude W*	*Number*
64°00′	20°00′	1
66°20′	19°30′	1

Table 4. Locations and magnitudes of earthquakes.

2. Describe the pattern formed by the intensity and number of earthquakes as they have occurred across Iceland.

3. Where do you think the Mid-Atlantic Ridge crosses Iceland? Shade in a zone on your map to indicate the ridge.

4. Can you tell if Iceland is spreading apart? Explain.

5. If you were building a house in Iceland, what areas would you avoid? Why?

SUMMARY QUESTIONS

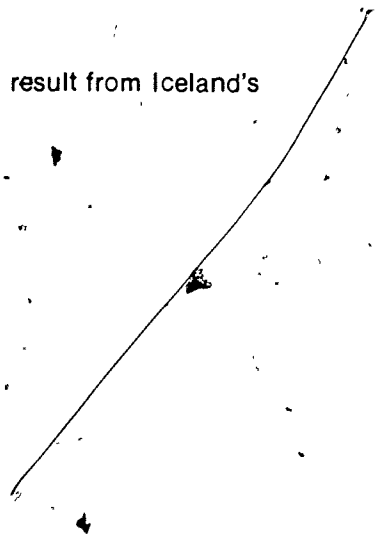
1. Several different kinds of data have been used in this investigation. Which types seem to be most useful in determining the location of the ridge?

2. What types of geological activity would you expect to occur along the Mid-Atlantic Ridge south and north of Iceland?

3. Volcanic rock on Iceland in general becomes older the farther it is from the active zones. Volcanoes located on the west coast are an exception. How can their young age be explained?

4. What is the source of the hot water that provides much of the energy used in Iceland?

5. What geologic hazards result from Iceland's position on the ridge?



6. Where would you locate an expensive factory that required great quantities of heat energy?

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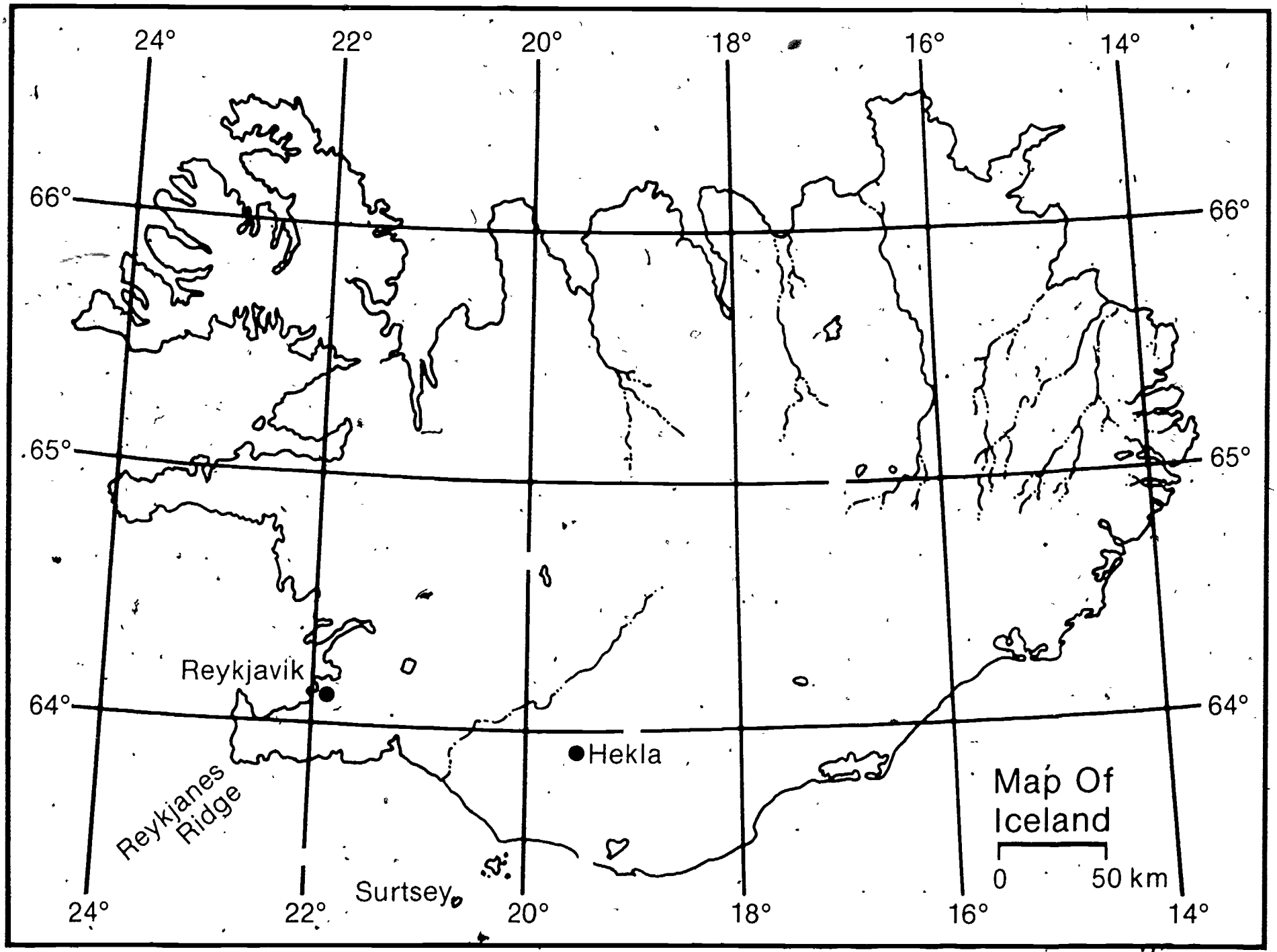
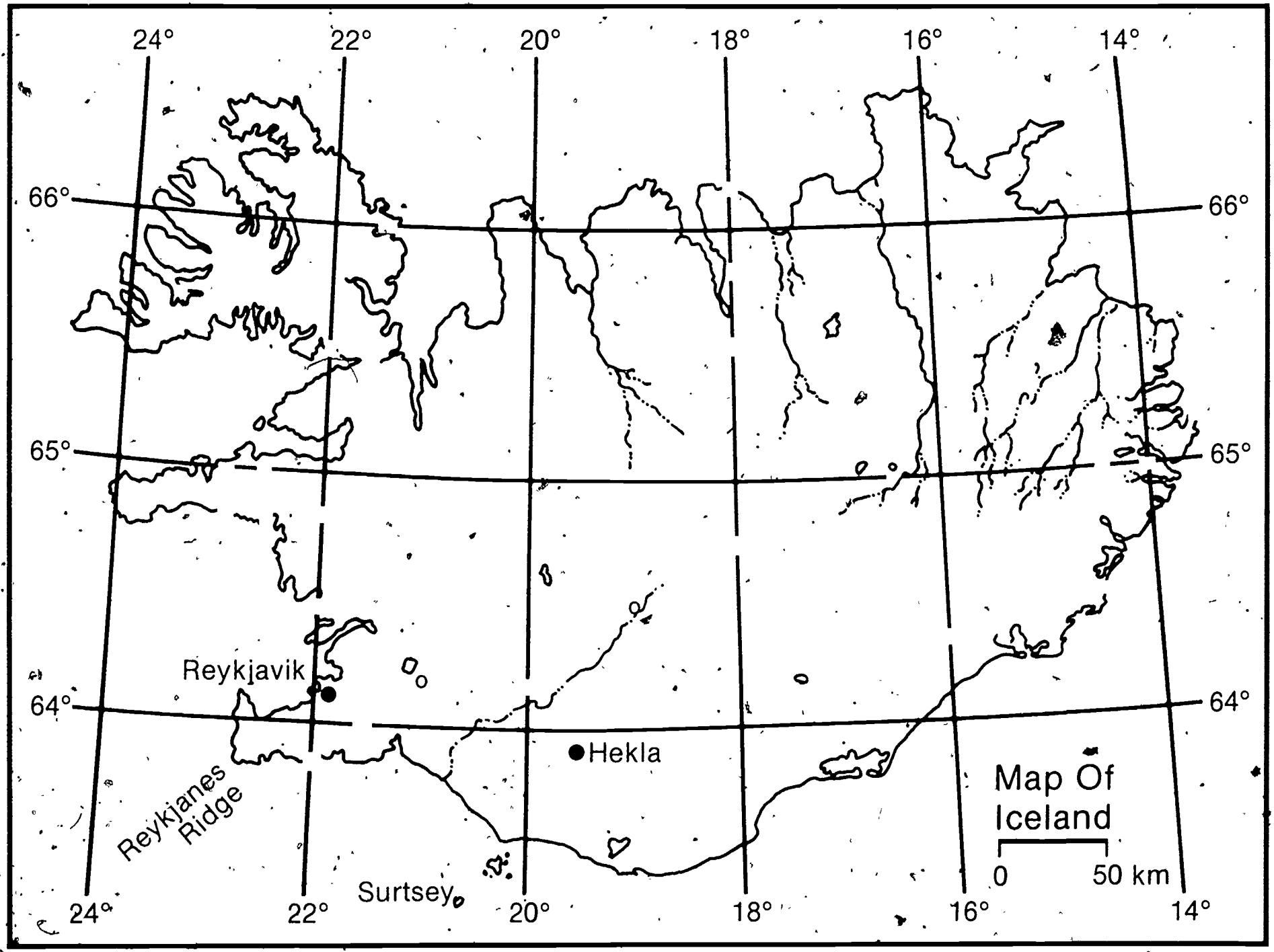
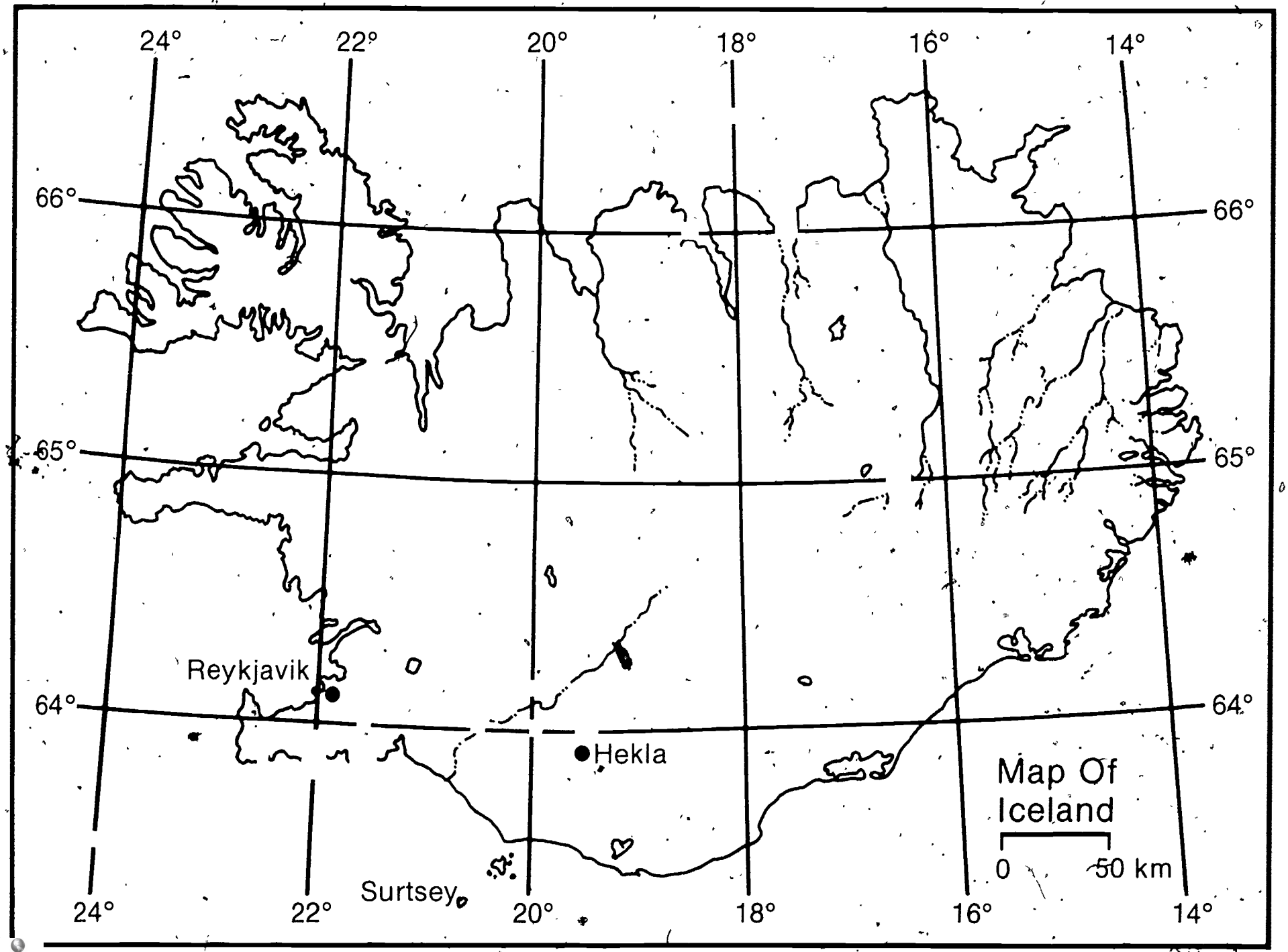


ksheet 1 (PART A)



ksheet 2 (PART B)


24°
22°
20°
18°
16°
14°
66°
65°
64°
Reykjavik
Hekla
Surtsey
Map Of
Iceland
0
50 km