Maine Geological Survey
DEPARTMENT OF CONSERVATION
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OPEN-FILE NO. 80-36

Title: Geologic Structure of the Chain of Ponds Pluton and Vicinity, Northwestern Maine

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Date: 1980

Financial Support: Preparation of this report was supported by funds furnished by the Nuclear Regulatory Commission, Grant No. NRC-04-76-291.

This report is preliminary and has not been edited or reviewed for conformity with Maine Geological Survey standards.

Contents: 34 page report and map

INTRODUCTION

On June 15, 1973, an earthquake occurred along the Maine-Quebec border which was felt as far away as 300 km. The maximum intensity (VI) was experienced by residents in and north of Woburn, Quebec, and the quake was reported to have a magnitude of 4.8 (Wetmiller, 1975). The following report is the result of geologic bedrock mapping and lineament analysis carried out along the Maine-Quebec border during the summer of 1979, with emphasis on fault and lineament occurrence and trends related to physiographic and topographic characteristics in the seismically active area.

The Maine-Quebec border in northwestern Maine is a watershed divide. Topography on the northern (Canadian) side is generally low-lying, glacially covered terrain, the geology of which has been previously mapped by Marleau (1959, 1968) and, more recently, by Cheve (1978). Access in this area is limited and most of my work in Canada was made possible by permission of the Megantic Manufacturing Company. On the southern and eastern side of the border (in Maine), the topography has rugged relief with strong bedrock control. Access is limited and permission from local fish and game clubs and from lumber companies was much appreciated. Previous work by Harwood (1973) covered the western portion of the study area. The entire section of the international border through the study area was traversed with access from both Maine and Quebec.

ROCK STRATIGRAPHY

Geologic Setting

The study area is located at the western end of the "Chain Lakes massif" of Boone and others (1970), which marks the core of the Boundary Mountain Anticlinorium (Albee, 1961). This core consists primarily of mafic and felsic metavolcanics, gneisses, and ultramafics, and has been assigned a Precambrian age (Naylor and others, 1973). Younger granitic rocks intruded the eastern end of the massif during the Ordovician (the Attean Quartz Monzonite of Albee and Boudette (1972)) and the western end during the Devonian (the Seven Ponds Pluton of Harwood (1973) and the Spider Lake Granite of Marleau (1959)). The massif is flanked on the northwest by Devonian metasediments of the Seboomook Formation with local slivers of Silurian limestone (Albee and Boudette, 1972; Westerman, 1979). The contact between the basement rocks and the younger metasediments to the northwest has been considered by Rodgers (1970) to be a southeast-dipping thrust fault, by Boone and others (1970) and by Boone (1978) to be a northwest-dipping thrust fault, and by Albee and Boudette (1972) to be both a depositional unconformity and a northwest-dipping thrust fault in the Attean area. Westerman (1979) reported evidence which suggested that the contact is a steep, northwesterly-dipping normal fault in the Skinner area.

Description of Formations

Arnold River Formation - The oldest rocks in the study area are metavolcanics, gneisses and massive granulites of the "Chain Lakes massif", a term introduced by Boone and others (1970) to designate the "basement complex" of Boucot (1953). The gneisses and granulites of this unit are characterized by the ubiquitous presence of quartz eyes and lithic fragments. The name Arnold River Formation was introduced by Marleau (1959) for rocks of this basement complex exposed to the west of the study area in Quebec. Marleau mapped these rocks eastward to the Maine border, as did Cheve (1978), who further extended mapping of the formation to the east side of the Spider Lake Granite in the northern portion of the study area (see figures 1 and 2). These rocks are similar in all ways to units in the Chain Lakes massif described by Boone and others (1970) and by Boudette and Boone (1976), and they are equivalent to the Magalloway Mamber of the Dixville Formation of Harwood (1969, 1973).

The rocks of the Arnold River Formation occur in four distinct structural settings within the study area, the last three of these having produced a characteristic imprint on the more original nature of the rocks. These settings are: (1) outside the contact aureoles of younger plutons, (2) within the contact aureoles of younger plutons, (3) as xenoliths in the younger plutons, and (4) close to the northwest margin of the formation where it is in contact with the post-Upper Silurian metasedimentary rocks.

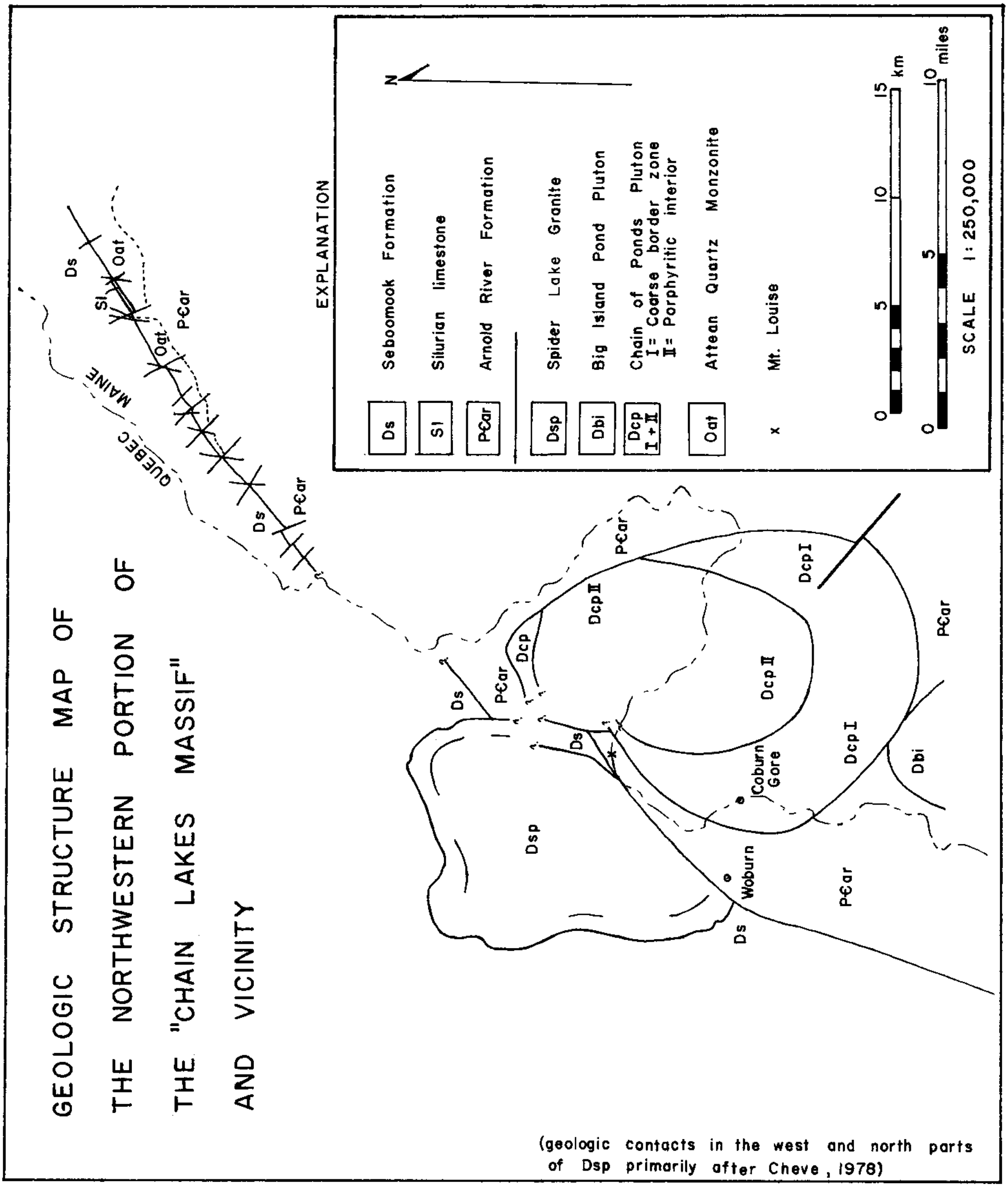
The external margin of the contact metamorphic effects is defined for this report as the local biotite isograd. Rocks of the Arnold River Formation located outside this isograd are at the chlorite grade and are characteristically grayish green in color. They consist of well-bedded metavolcaniclastics in the southeastern portion of the study area, exposed in Gold Brook and in roadcuts along the north shore of Chain Lakes. Abundant quartz pods up to 10 cm in length and minor lithic fragments occur in a quartz-feldspar-chlorite matrix. The rocks exhibit a well-developed gneissic foliation roughly parallel to the steeply dipping beds.

Within contact aureoles, rocks of the Arnold River Formation are further characterized by a prominent black and white gneissic layering amplified by the color contrast of biotite-rich and biotite-poor layers. The scale of this layering, typically 1-2 mm, and the degree of its development generally increase as plutonic masses are approached. This texture only rarely disturbs the original compositional layering which is commonly evidenced by the concentrations of elongated lithic fragments. These fragments are typically gneiss and greenstone which vary in shape from rounded to highly angular, with sizes generally falling in the range of 5 to 30 cm. Blocks up to 10 m in length were rarely observed. Other lithologic characteristics commonly observed include mafic schlieren, feldspar crystals up to 2 cm, and mixed gneissic and sugary granofels texture. Within a few meters of igneous contacts, granofels texture becomes more prominent, rare evidence of granitization can be found, and bedding becomes obscured.

Numerous angular xenoliths of the Arnold River Formation occur in the outer border zone of the Chain of Ponds Pluton, and their characteristics are generally similar to the rocks in the inner portion of the contact aureole. The sizes of these xenoliths typically exceed 10 m in all dimensions. Quartzofeldspathic biotite gneiss with a well-developed swirly black and white layering is the dominant rock type. Grain size and gneissosity are generally amplified in the xenoliths, although granofels texture still exhibiting quartz eyes and lithic shadows is common.

The northwestern most exposures of the Arnold River Formation, along the Maine-Quebec border between Coburn Gore and Mt. Louise, are characterized by having a schistose texture. The foliation parallels the original bedding of

FIGURE 1



GEOLOGIC STRUCTURE MAP OF THE NORTHWESTERN PORTION OF THE "CHAIN LAKES MASSIF" AND VICINITY

(geologic contacts in the west and north parts of Dsp primarily after Cheve, 1978) these metavolcaniclactics and has been deformed subsequent to its formation, as evidenced by changes in orientation from approximately N. 55° E. to N. 35° E on a scale of hundreds of meters. The quartz eyes, lithic fragments, and mafic schlieren have survived the development of the schistose texture, the surfaces of which frequently indicate both normal (northwest side down) and right-lateral movement. Exposures of the Arnold River Formation near the contact with Devonian age rocks in the northern portion of the study area (east of the Spider Lake Granite) are further characterized by high percentages of near-vertical quartz veins parallel to the foliation of the schistose gneiss.

A rare occurrence of amphibolite in the Arnold River Formation is located within 20 m of the contact with Devonian metasediments southwest of Mt. Louise along the international border (Figure 2). One exposure of felsic metavolcanics (porphyritic quartz latite (?)) was mapped in the northeastern corner of the study area (Figure 2). These pale yellowish felsic rocks which weather pink are similar to rocks occurring to the northeast in the Skinner area (Westerman, 1979) and to the southwest in Quebec (Cheve, 1978).

Seboomook Formation - Perkins (1925) applied the name Seboomook Slate to interbedded dark-gray sandstone and slate exposed at Seboomook Dam, about 50 km northeast of Jackman, Maine. Boucot (1961) mapped the extension of this unit southwest into the Attean Quadrangle, applying the name Seboomook Formation. This formation has subsequently been mapped further to the west (Westerman, 1979) and into the present study area (Cheve, 1978).

The Seboomook Formation occurs in two regions within the study area, separated by the Spider Lake Granite. A narrow band of outcrops was mapped south of that pluton in the vicinity of Mt. Louise where these Devonian metasediments occur in contact with the Arnold River Formation, within the contact aureole of the Chain of Ponds Pluton. They are here characterized by a purplish color due to the development of contact metamorphic biotite. The rocks are typically well bedded (1 to 10 cm) with steep dips, and they consist of biotite-cordierite schists, biotite-muscovite schists, metasandstones, metasiltstones, and metapelites, all of which are hornfelsed. The development of cordierite in the biotite-rich pelitic units is diagnostic within the contact aureoles of adjacent plutons. Similar hornfelsed rocks are exposed south of Woburn, Quebec, at the south end of the Spider Lake Granite, which truncates the Seboomook Formation (Cheve, 1978). Beds of the Seboomook Formation near Mt. Louise generally strike roughly parallel to the contact with the Arnold River Formation (approximately N. 45° E.), but swing to N. 10° E. at the eastern margin of the outcrop belt. This change in orientation appears to be due to a combination of faulting and igneous intrusion.

On the east side of the Spider Lake Granite in the northernmost part of the study area, outcrops of dark-gray slate are assigned to the Seboomook Formation. Quartz veins are abundant as 1 mm streaks parallel to the cleavage and in east-west fractures marking the hinges of minor folds. These folds, with dominant limbs N. 42° E., 90°, and minor limbs N. 12° E., 73° E., reflect the local deformation of the regional trend, to be discussed below in greater detail. A polymictic, pebble-cobble conglomerate separates the slate from the gneiss of the Arnold River Formation to the south. This unit, which has a maximum thickness of 20 m, contains ellipsoidal pebbles and cobbles of fine-grained metaquartzite, coarse-grained metasandstone and fine-grained siliceous metalimestone in a cherty matrix. The occurrence of a conglomerate in this stratigraphic position suggests the possibility of a basal depositional unit resting unconformably on the basement.

Igneous Rocks - Three individual plutons are designated in this report: the Spider Lake Granite located in Quebec in the northwestern part of the study area, the Chain of Ponds Pluton in the central part, and the Big Island Pond Pluton along the southern boundary of the study area. All three plutons are genetically related and may be physically connected. The Chain of Ponds Pluton and the Big Island Pond Pluton are subdivisions of the Seven Ponds Pluton of Harwood (1973). The bases for this subdivision are discussed below.

The western portion of the Chain of Ponds Pluton was mapped by Harwood (1973), and extension of that work by this author produced the following description. The external margin of the Chain of Ponds Pluton has the shape of a distorted circle with a somewhat irregular and, in part, fault-bounded northern boundary. The pluton is concentrically zoned, a feature earlier recognized by Harwood (1973). The innermost zone is fine to medium-grained granodiorite with accessory euhedral sphene. This core grades outward to a porphyritic granodiorite with hornblende and Na-rich feldspar phenocrysts and accessory sphene. The percentage of phenocrysts increases toward the external margin of this zone, as does their size. In the southwestern portion of the pluton, the porphyritic zone appears to grade into a coarse-grained quartz monzonite (noted by Harwood, 1973), but in the western portion the change occurs more abruptly. An intrusive contact between the two units is exposed in Quebec in the northeastern portion of the pluton. The external part of the porphyritic zone frequently exhibits a nearly vertical foliation seen as aligned phenocrysts, with the foliation trending parallel to the concentric zonation of the pluton.

The external border zone of the Chain of Ponds Pluton consists of coarse-grained quartz monzonite and quartz monzonite porphyry, flecked with black biotite. It is characterized by subhedral to euhedral feldspar, and by abundant, large xenoliths. These xenoliths are conspicuously absent in the internal zones of the pluton and in the other plutonic masses in the study area. The vast majority of the xenoliths are quartzofeldspathic biotite gneiss of the Arnold River Formation, but blocks of serpentinized ultramafics and Devonian (?) metasediments are also present. Harwood (1973) presents detailed maps of such xenoliths in parts of the western portion of the pluton. The presence of younger metasedimentary xenoliths in the southeastern, as well as southwestern and western, portions of the pluton has structural significance. The occurrence of such angular xenoliths and the nearly circular map view of the pluton suggests that the outer quartz monzonite zone was emplaced by stoping, requiring that the relatively undeformed metasediments were physically located above their present position. Some of these metasedimentary xenoliths occur as much as 14 km southeast of the nearest bedrock exposures of similar Devonian metasediments.

The external border zone is not present around the entire perimeter of the Chain of Ponds Pluton. Its shape is that of a crescent, opening northward such that the porphyritic granodiorite zone comes in direct contact with the Arnold River Formation along the northeastern margin of the pluton. A coarse-grained granite occurs as a border to the granodiorite at its northern limit, but that granite was not observed to contain either xenoliths or euhedral feldspar crystals. It is lithologically similar to the coarse granite which forms a border zone on the Spider Lake Granite. The nature of the northwest margin of the Chain of Ponds Pluton is unclear. Granite dikes, trending N. 0-20° E. are present, but the lack of exposure in the lowlands of the Spider River does not permit detailed mapping.

A body of coarse-grained quartz monzonite is exposed at the southwestern margin of the Chain of Ponds Pluton. Its map view, as shown by Harwood (1969), is roughly circular, and it is hereafter referred to in this report as the Big Island Pond Pluton. These plutons can be seen in Figures 1 and 2 to be in contact over a distance of 1 km, but they are separated into different map units primarily on two bases. The feldspar crystals in that portion of the Big Island Pond Pluton investigated in this study lack the euhedral character observed in the Chain of Ponds Pluton, and xenoliths were not observed in the Big Island Pond Pluton. Detailed mapping of the contacts of these two plutons reveals that they approach each other tangentially.

The map view of the external contacts of the Spider Lake Granite presented in Figure 1 is after Cheve (1978) with only minor modification as a result of this study. Reconnaissance mapping by this author, in the company of Mr. Serge Cheve, revealed a zonation in that granite with a porphyritic granodiorite core that in all respects correlates with the internal porphyritic zone of the Chain of Ponds Pluton. These internal zones apparently had a single magma source, and were most likely emplaced contemporaneously. A course-grained granite border zone was observed along the northern border of the Spider Lake Granite, and this zone is lithologically similar to the northern border of the Chain of Ponds Pluton described above. Minimal exposure over much of the region underlain by the Spider Lake Granite has not permitted detailed mapping of its internal zonation, but the northwestern, western and southern borders were observed to consist of medium to coarse-grained granite rather than granodiorite. No xenoliths were observed in the Spider Lake Granite, which is almost entirely enclosed by mid-Paleozoic metasediments.

Dikes observed to occur in the Arnold River Formation included fine-grained porphyritic felsites with biotite and/or feldspar phenocrysts, fine to coarse-grained granites, basalt, chloritized basalt, porphyritic basalt with plagioclase phenocrysts, and greenstone. This list is in order of decreasing abundance and degree of freshness. Pegmatite, aplite and quartz-epidote-pyrite viens were also observed in this formation. Several varieties of dikes were observed in the coarse-grained border zone of the Chain of Ponds Pluton (see Figure 2), most importantly the medium-grained granodiorites with minor phenocrysts of feldspar and hornblende similar to rocks in the internal zone of the pluton. Several aplite veins, porphyritic felsite, granite and basalt dikes were mapped in the coarse quartz monzonite zone. One basalt (lamprophyre) dike was located in the internal porphyritic granodiorite zone of the Chain of Ponds Pluton, but no dikes were observed in the Spider Lake Granite, the Big Island Pond Pluton, or the Seboomook Formation.

STRUCTURAL GEOLOGY

In order to better understand the structural setting within which seismic activity has recently occurred along the northwest Maine-Quebec border, this study was carried out at two scales. The geometric relationships of the major lithologic units and the history which led to their present distribution was the larger scale effort. Detailed mapping of the contact between the Arnold River Formation (Precambrian) and the Seboomook Formation (Devonian), the external contacts and internal lithologic structures of the plutons, and the distribution of dikes related to these plutons was critical in evaluating this history. The smaller scale aspect of the study involved the brittle fractures which have been imprinted on the rocks subsequent to the development of the major structural setting. Mapping of fracture cleavage indicating movement from compressional stress; dikes, quartz-coated joints, and normal faults indicating movement from tensional stress; and smooth joints indicating fracture with no determinable sense of stress was done throughout the study area. The results from the two approaches were compared to analyze for persisting zones and/or directions of brittle fracture.

Large Scale Geologic Structural History

The largest structural feature within the study area is the contact between the Arnold River Formation and the Seboomook Formation, representing the northwest margin of the core of the Boundary Mountain Anticlinorium. This anticlinorium is defined by the structural relations of the base of the Silurian and Devonian rocks which surround the core of older rocks, not necessarily by its internal structures (Albee, 1961). No evidence of major internal structure was found in the Arnold River Formation within the study area, and mapping efforts focused on its northwest contact with the Seboomook Formation. The trace of this contact generally trends northeast with apparent left-lateral offsets trending N. 10-15° E. in places associated with plutonic activity. The northeast trending segments are sharp and straight with tight map control on their locations. The foliations of the rocks on both sides strike roughly parallel to the contact and dip very steeply, and these rocks commonly contain higher than average amounts of vein quartz. No evidence was observed of shallow-angle fracture systems near the contact or elsewhere in the study area. One of the apparent left-lateral offsets in the contact occurs NNE of Mt. Louise (Figure 1), separating the Chain of Ponds Pluton and the Spider Lake Granite. The foliation of the Seboomook Formation exposed along the western side of this offset trends parallel to it (N. 13° E.). These facts lead to the interpretation that the contact between the Arnold River Formation and the Seboomook Formation is a high angle normal fault along which the northwest side has been dropped down to bring Devonian age rocks into contact with Precambrian age rocks. The offset in this contact is interpreted to be a "hinge" fault which developed during the rise of the Chain Lakes massif.

The distribution of the plutonic bodies in the study area, and their histories which led to this distribution, are integral to understanding the geometry of the present structural setting. The Chain of Ponds Pluton is roughly circular in shape and is located southeast of the hinge mentioned above. Its shape is similar to that of the Big Island Pond Pluton located at its southwestern contact along the southern extension of the hinge. The coarse-grained quartz monzonite border zone of the Chain of Ponds Pluton, with its abundant xenoliths, was the first portion of the pluton to be emplaced as evidenced by the occurrence in those rocks of porphyritic granodiorite dikes derived from the interior. This border zone was apparently emplaced by a stoping mechanism associated with nearly circular fracturing in the relatively uniform massif. The coarse grain size of the quartz monzonite, even in the presence of abundant heat-absorbing xenoliths, suggests emplacement at a deep level. The contact aureole (biotite grade) is imprinted on a regional chlorite grade (albeit retrograde), fixing the depth at the time of emplacement between 15 and 30 km (Hyndman, 1972, p. 313). The pluton is entirely surrounded by the Arnold River Formation, but the presence of relatively undeformed metasedimentary xenoliths requires that younger sedimentary units previously overlay the Arnold River Formation.

The intrusion of the porphyritic granodiorite magma into the central portion of the Chain of Ponds Pluton must have occurred while the central portion of the coarse quartz monzonite was still molten (to permit gradational contacts in the southwest) but while the external portion was solidified (to permit the emplacement of dikes and the intrusive contact in the northeast). This same magma formed the rocks in the central portion of the Spider Lake Granite in the Seboomook Formation and other formations of similar age. The two plutons come close to being and may be in contact at the hinge of the boundary fault.

Brittle Fracture Analysis

The orientations of brittle fractures, exclusive of foliation and cleavage, are illustrated for the study area in Figure 2. These data are also presented on contour diagrams (Figures 3 through 10) in which they have been separated by region and on the bases of their surface characteristics.

The three divisions of the brittle fractures are: (1) smooth fractures which have no indications of movement; (2) extensional fractures indicated by mineralization (quartz), injection (dikes and veins) or normal movement; and (3) compressional fractures with rough, chattery or slickensided surfaces indicating thrust, right-or left-lateral movement.

The brittle fractures in the Chain of Ponds Pluton can be seen in map view to have a pattern consisting of two dominant sets. The first set includes radiating and concentric joints which rarely indicate movement along their surfaces. There is a tendency for extensional joints containing dikes to parallel the radiating fractures. The second prominent set of brittle fractures consists of quartz-coated joints which trend N. 10° E. and N. 80° E., both dipping nearly vertically. These sets are best developed in the internal porphyritic granodiorite zone of the pluton, where they stand up as resistant ridges on the glacially smoothed, low lying outcrops. A third set of brittle fractures trends northwest, parallel to the prominent topographic low in the central and southeastern portion of the pluton. This feature, occupied by the North Branch Dead River, extends southeast for at least 40 km. A 350 m long, apparent left-lateral offset in the southeastern contact of the Chain of Ponds Pluton occurs along this lineament. The northwestern extension of the lineament projects along a topographic low, across the Quebec-Maine border, and on to the south end of Lake Megantic, but it is much less pronounced in the mountainous region near the border than it is in the glacially eroded drainage channel to the southeast. The prominence of the northwest-trending lineament is reduced in the western portion of the pluton where it intersects the north end of a second 40 km lineament which trends nearly due south and is occupied by the Kennebago River. An east-west lineament through the Coburn Gore border crossing joins the lineaments mentioned above, as does the southern extension of the topographic low marking the hinge offset in the border fault of the Chain Lakes massif. Figures 3A and 3B illustrate the correlation between the extensional and compressional brittle fractures in the Chain of Ponds Pluton and these topographic lineaments (see also Figure 3C). A similar fracture pattern can be seen in the northern portion of the Big Island Pond Pluton (Figure 4).

The orientations and character of brittle fractures in the Arnold River Formation surrounding the Chain of Ponds Pluton are presented in Figure 2 and are further illustrated with contour diagrams in Figures 5 through 10. These diagrams are arranged in sets representing six areas around the Chain of Ponds Pluton. The most prominent characteristic of these fractures is the concentric pattern of one set in outcrops located close to the pluton. The southeastern and eastern areas are characterized by east-west trending joints and N. 30° E. trending fracture cleavage and joints. Movement directions indicate both right- and left-lateral motion, generally on NE to NNE-trending fracture cleavage.

Brittle fractures in the north-northeast region (Figure 7) are more variable in orientation than in any other region. Trends, listed in order of decreasing dominance, are N. 72° E., N. 90° E., N. 13° W., N. 58° W., N. 40° W. and N. 20° E. Fracture cleavage is concentrated between NNW and WNW, and the greatest percentage of extensional fractures have orientations near N. 25° E., N. 0° E. and N. 60° E. Fractures indicating lateral motion are rare, with both right- and left-lateral orientations concentrated about N. 25° W.

The strongest brittle fracture trend in the northwest region of the Arnold River Formation is N. 45° E., parallel to the contacts with the Seboomook Formation on the northwest side and the Chain of Ponds Pluton on the southeast side. Other trends of joints are N. 60° W., N. 45° W. and N. 30° W. (Figure 8A). The largest concentration of quartz-coated joints in this area is N. 55-75° E., and dikes trend N. 0° E. to N. 30° E. Minor fractures indicating left- or right-lateral motion trend N. 35° E. and N. 30-40° W.

Brittle fractures with no indication of movement in the western region (Figure 9A) typically have the trends N. 70° E. (strongest), N. 35° E, N. 30° W. and N. 0° E. Fractures indicating lateral motion generally trend N. 0° E. to N. 30° W, approximately parallel to the contact with the Chain of Ponds Pluton. In the southwestern region (Figure 10A), the brittle fractures trend in all but northeasterly directions (the dominant trend of the gneissic foliation), and extensional fractures and dikes trend N. 0° E.

Figure 11 illustrates the orientations of all the dikes mapped in the Arnold River Formation surrounding the Chain of Ponds Pluton. Inasmuch as dikes are indicative of extensional fracturing, the two dominant trends (N. 10° W. and N. 55° E.) may represent a conjugate pair of fractures. The largest-scale NNE tensional zone (the "hinge") associated with the offset along the northern boundary of the Chain Lakes massif may be the central fracture system to which these dikes are related.

SUMMARY

The following sequence of events is proposed to have led to the present structural setting of the region.

1. The Arnold River Formation was deposited during the Precambrian in a region dominated by extensive, explosive volcanism, followed by deep burial, high-grade metamorphism, uplift with retrograde metamorphism, and erosion.

2. Subsidence of the region during the Silurian and into the Devonian resulted in the deposition of sedimentary units on the Arnold River Formation.

3. The Arnold River Formation in the Chain Lakes massif rose as a solid block, developing a normal fault along its northwest border. This boundary was offset by hinge faults resulting from differential rates of uplift within the massif.

4. During the rise of the massif, the associated pressure reduction (augmented by the hinge faulting and normal faulting) caused melting at depth. The highest level melts had quartz monzonite compositions and they rose in the weak zone of the hinge fault and by cylindrical fracturing and stoping.

5. Granodiorite melt from lower levels migrated up the conduit prepared by the coarse quartz monzonite, forming the core of the Chain of Ponds Pluton. This same magma migrated up on the north side of the boundary fault, following the conduit of an earlier granitic melt, to form the core of the Spider Lake Granite. The somewhat elongated and irregular shape of this latter pluton was due to the nature of the strongly foliated rocks which it intruded, primarily by forceful injection.

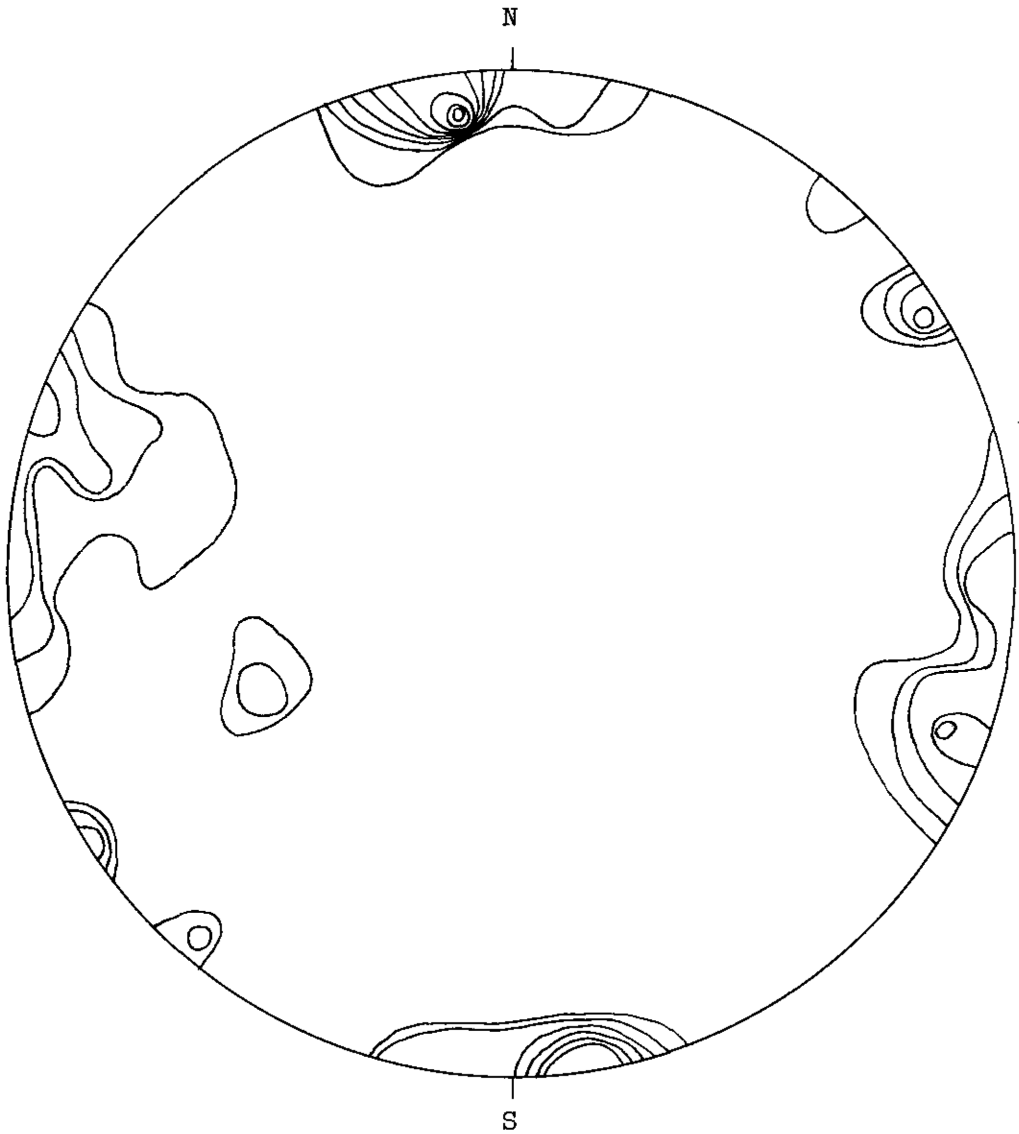
6. Continued activity of the hinge fault permitted the emplacement of younger dikes in its vicinity.

The geometric structure resulting from the proposed events can be described as follows. Two major tectonic blocks, each with radically different physical characteristics, are in near-vertical contact with hinges causing apparent offsets in their boundary. Nearly vertical, cylindrical plutonic masses, namely the Chain of Ponds Pluton and the Spider Lake Granite, are presently located on opposite sides of one such offset. The Big Island Pond Pluton occurs along the southern extension of this offset in contact with the Chain of Ponds Pluton. These three plutons are massive and relatively homogeneous in structure compared to the rocks in which they are enclosed. If regional stress is accumulating, then it seems likely that it would be released in areas of such relatively simple geometry where structural discontinuities are concentrated. Despite this interpretation of the region having a higher than average probability for seismic activity, no evidence of postglacial deformation of the bedrock was observed.

ACKNOWLEDGMENTS

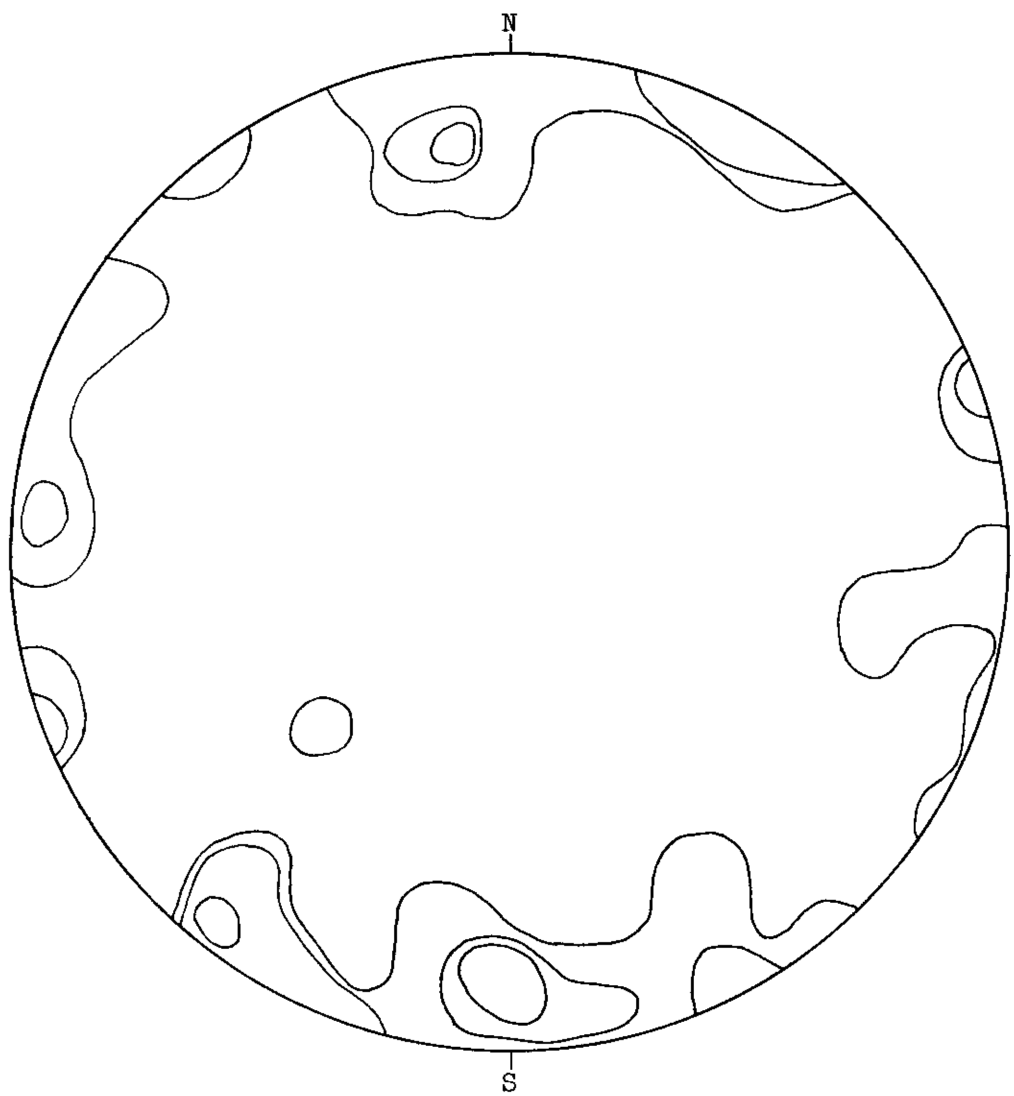
This work was supported by the U.S. Nuclear Regulatory Commission and the Maine Geological Survey, and I wish to thank Walter A. Anderson for this support. I was capably assisted in the field for a portion of the season by John Beane, for which I am grateful. I would particularly like to thank Walter Trzcienski, Jr. and Serge Cheve of Ecole Polytechnique in Montreal, Canada, for spending two days showing me the rocks of and near the Spider Lake Granite. Special thanks is also due to M. Forest of Megantic Manufacturing for access to the lands of that company.

FIGURE 3A



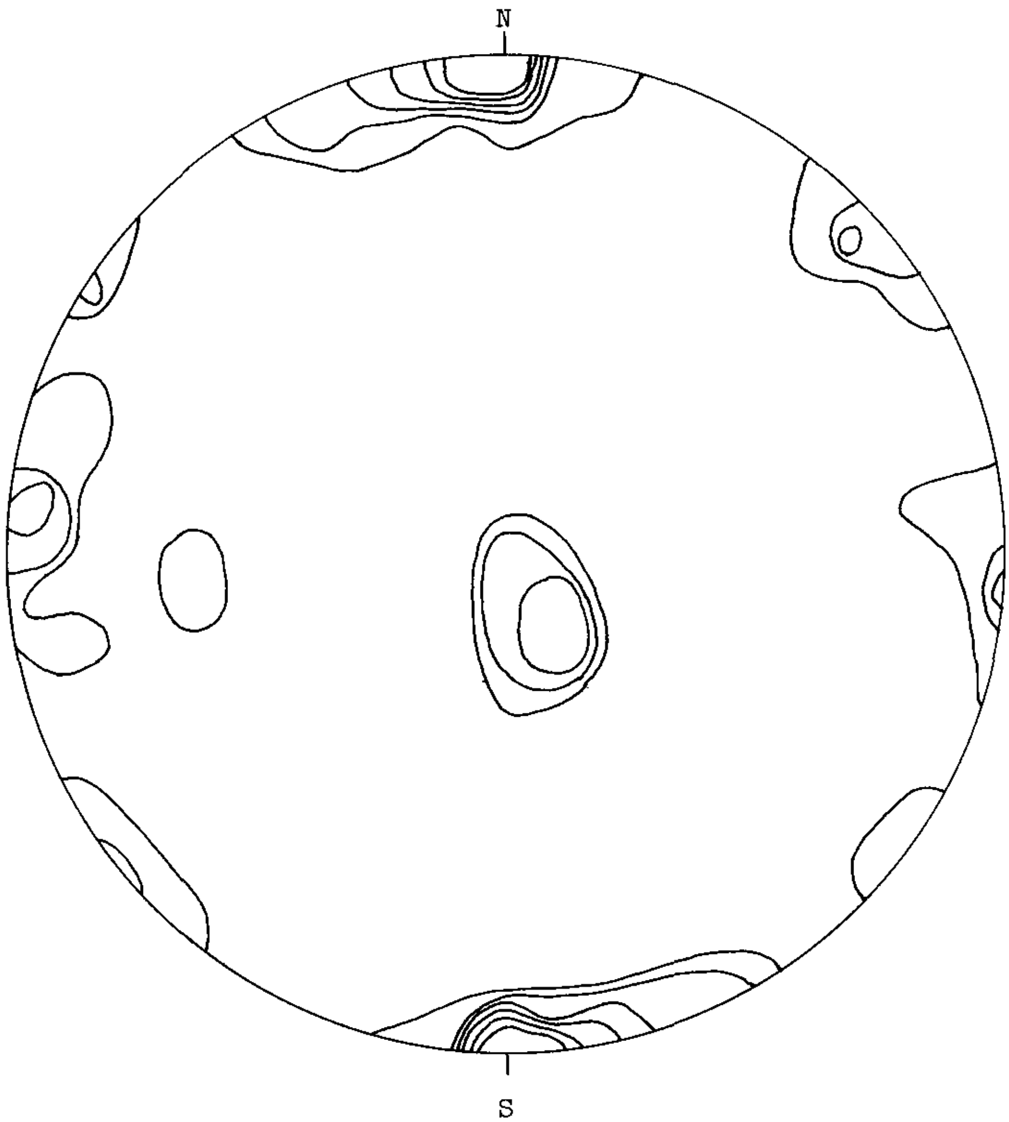
Contour diagram of extensional joints (including dikes) for the Chain of Ponds Pluton. Contours represent 3, 6, 9, 12 and 15% of the 66 measurements.

FIGURE 3B



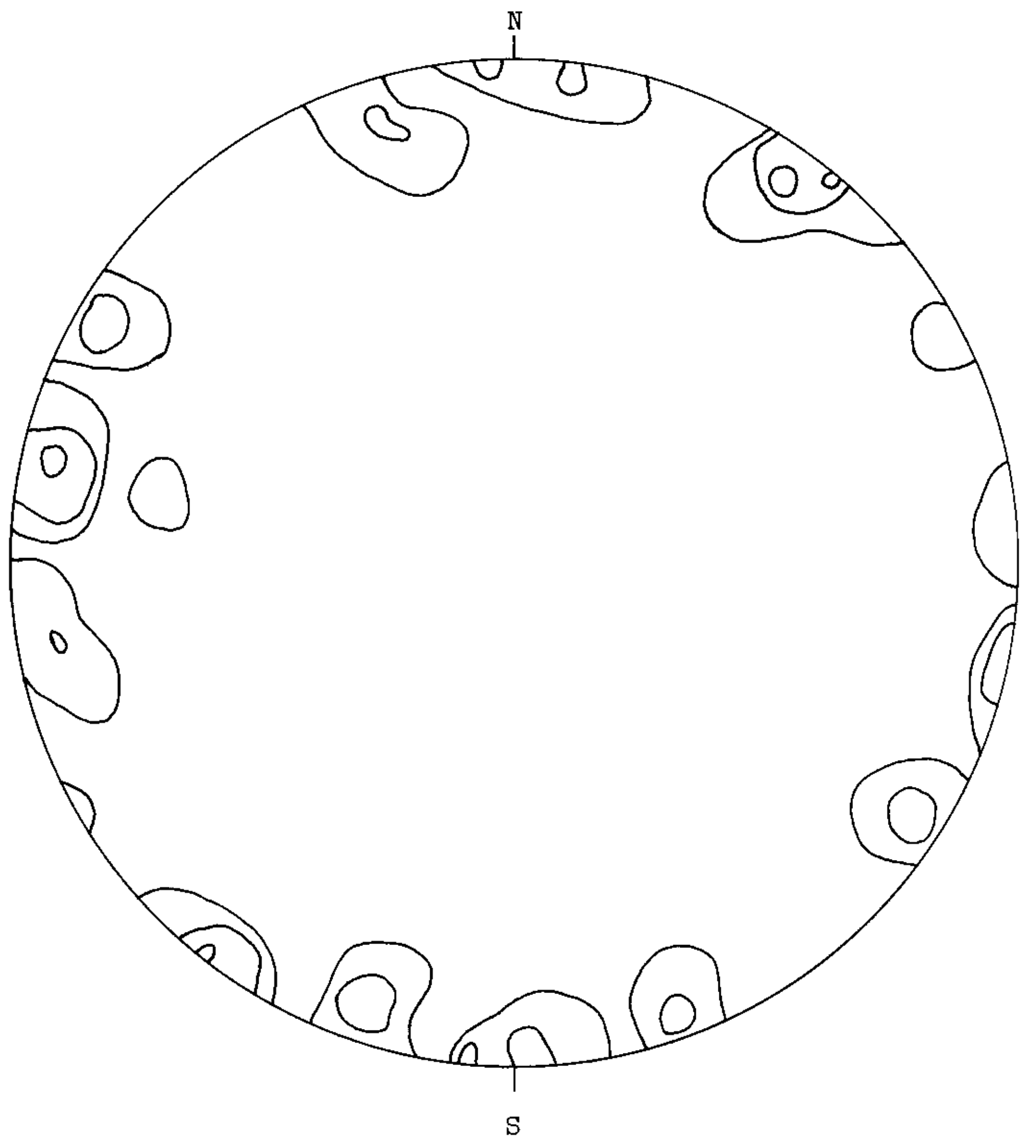
Contour diagram of compressional joints for the Chain of Ponds Pluton. Contours represent 4, 8 and 12% of the 26 measurements.

FIGURE 3C



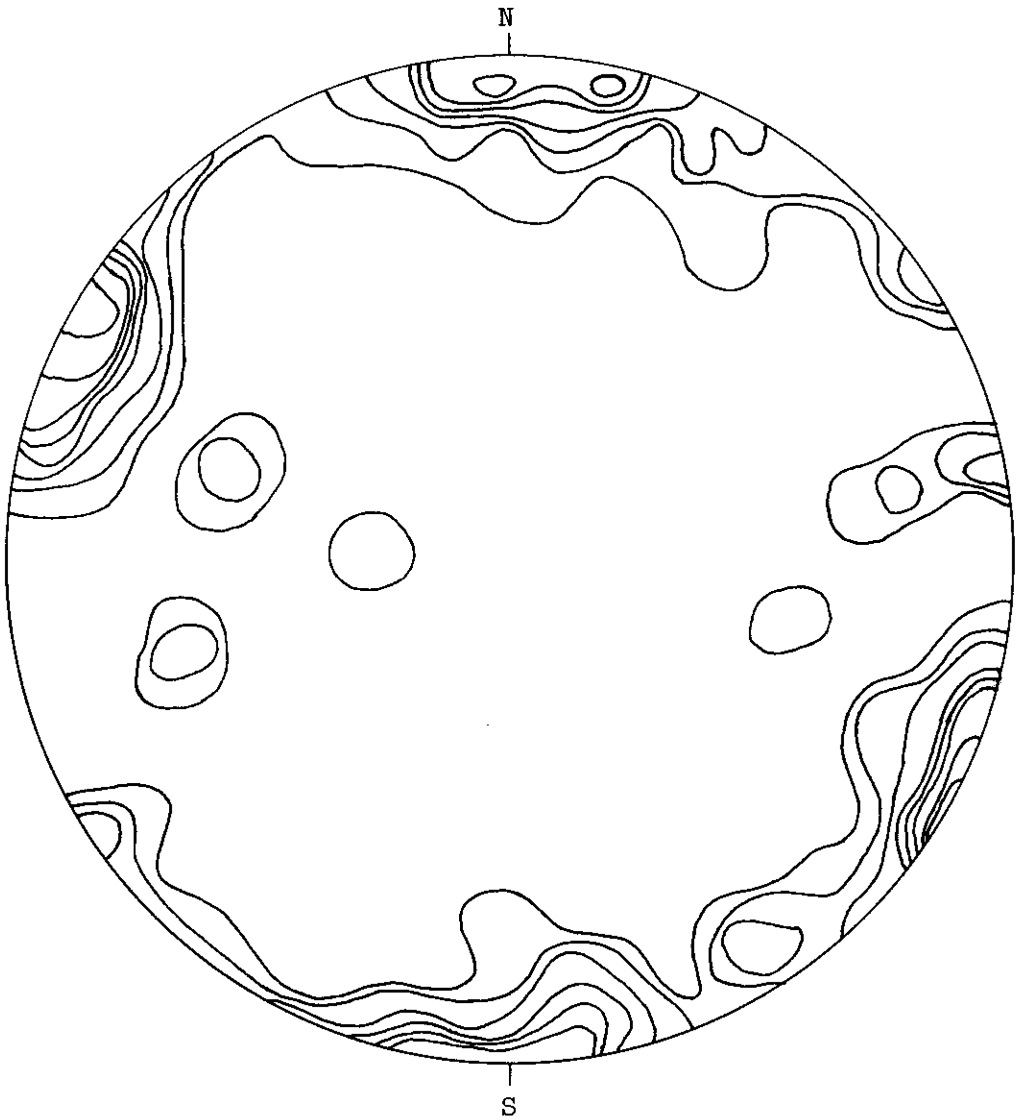
Contour diagram of all joints in the southern portion of the external coarse border zone of the Chain of Ponds Pluton. Contours represent 2, 4, 5.6, 7.1, 8.7 and 10.3% of the 124 measurements.

FIGURE 4



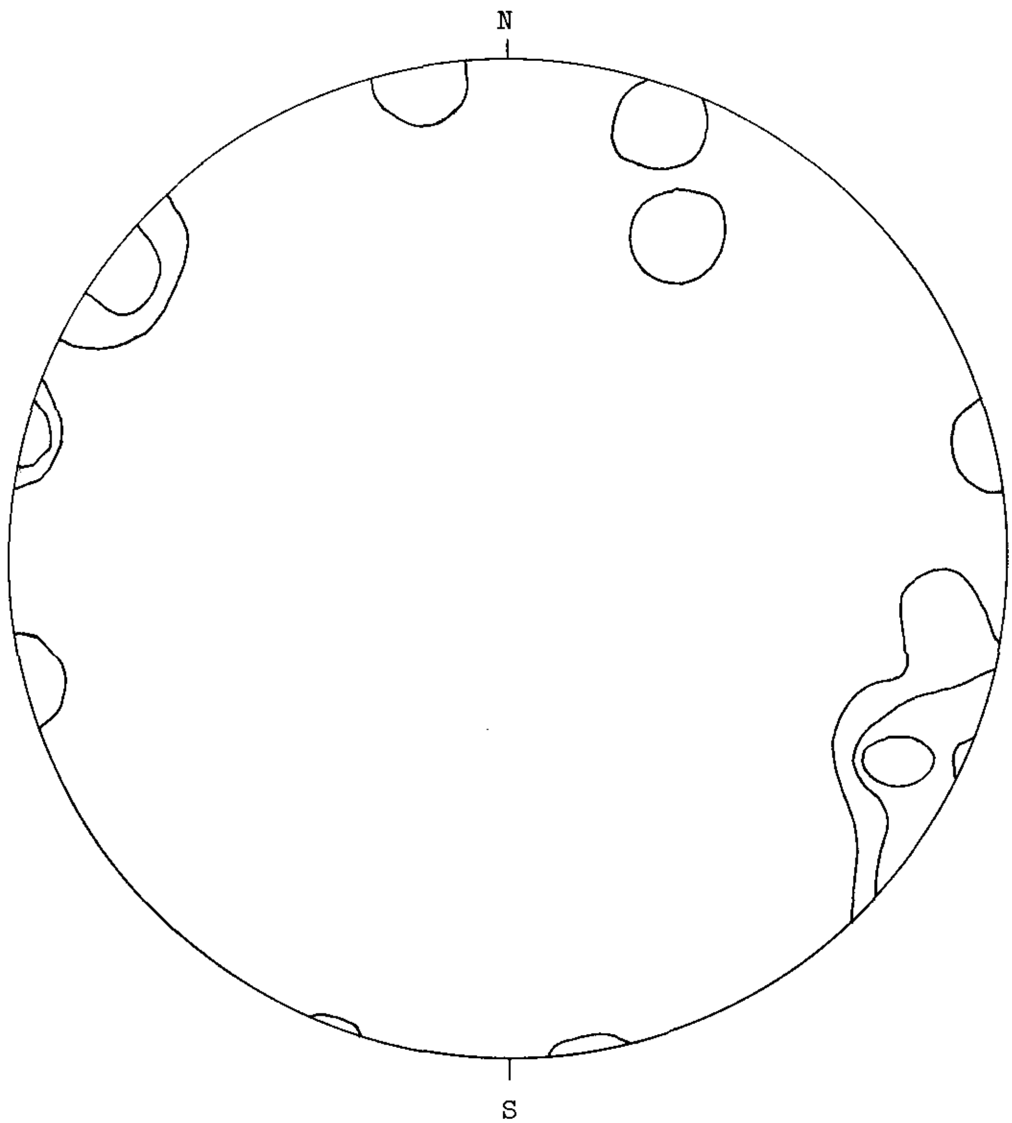
Contour diagram of all joints for the Big Island Pond Pluton. Contours represent 4.5, 9 and 13.5% of the 22 measurements.

FIGURE 5A



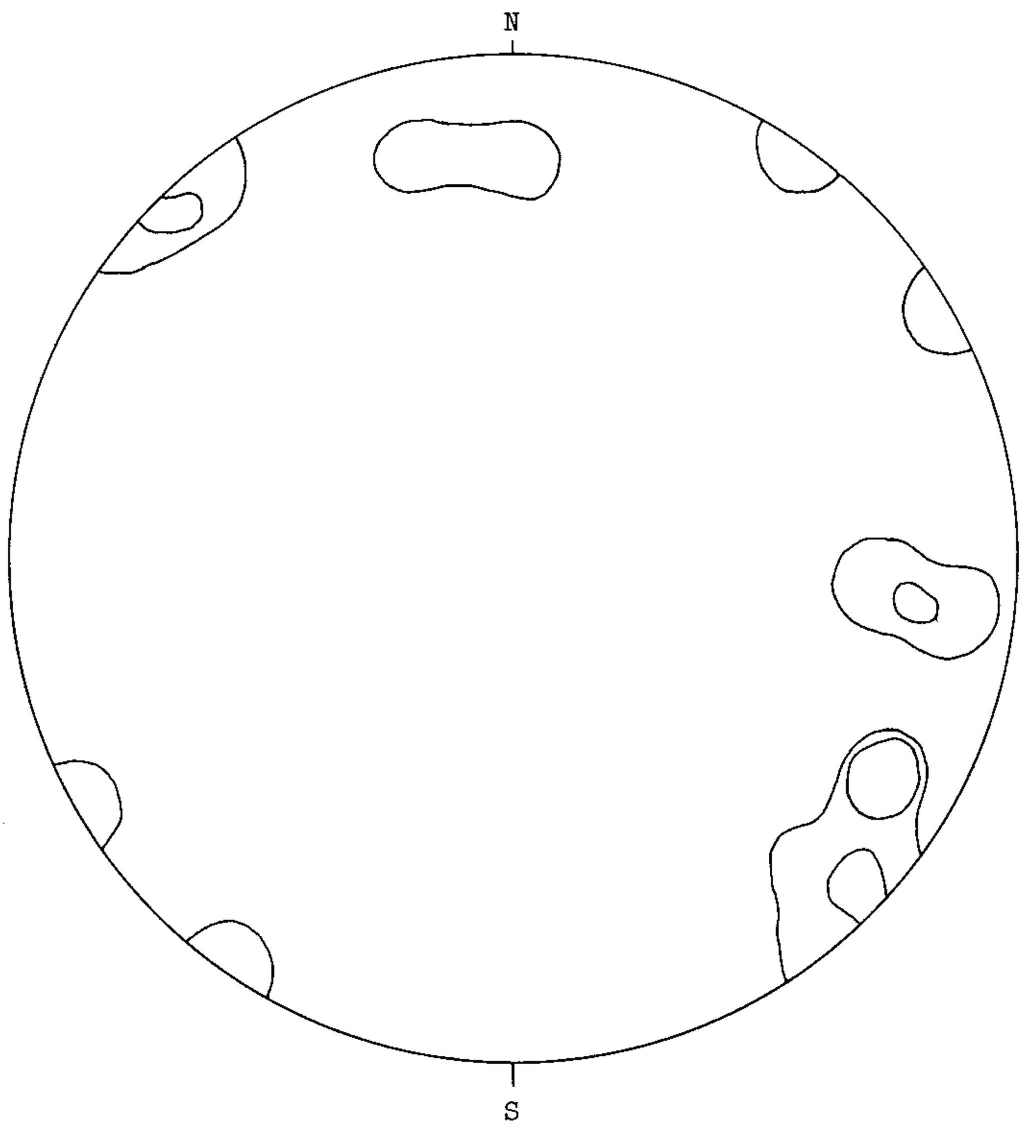
Contour diagram of smooth brittle fractures in the Arnold River Formation southeast of the Chain of Ponds Pluton. Contours represent 1.4, 2.8, 4.2, 5.6, 7.0, 8.4 and 9.8% of the 72 measurements.

FIGURE 5B



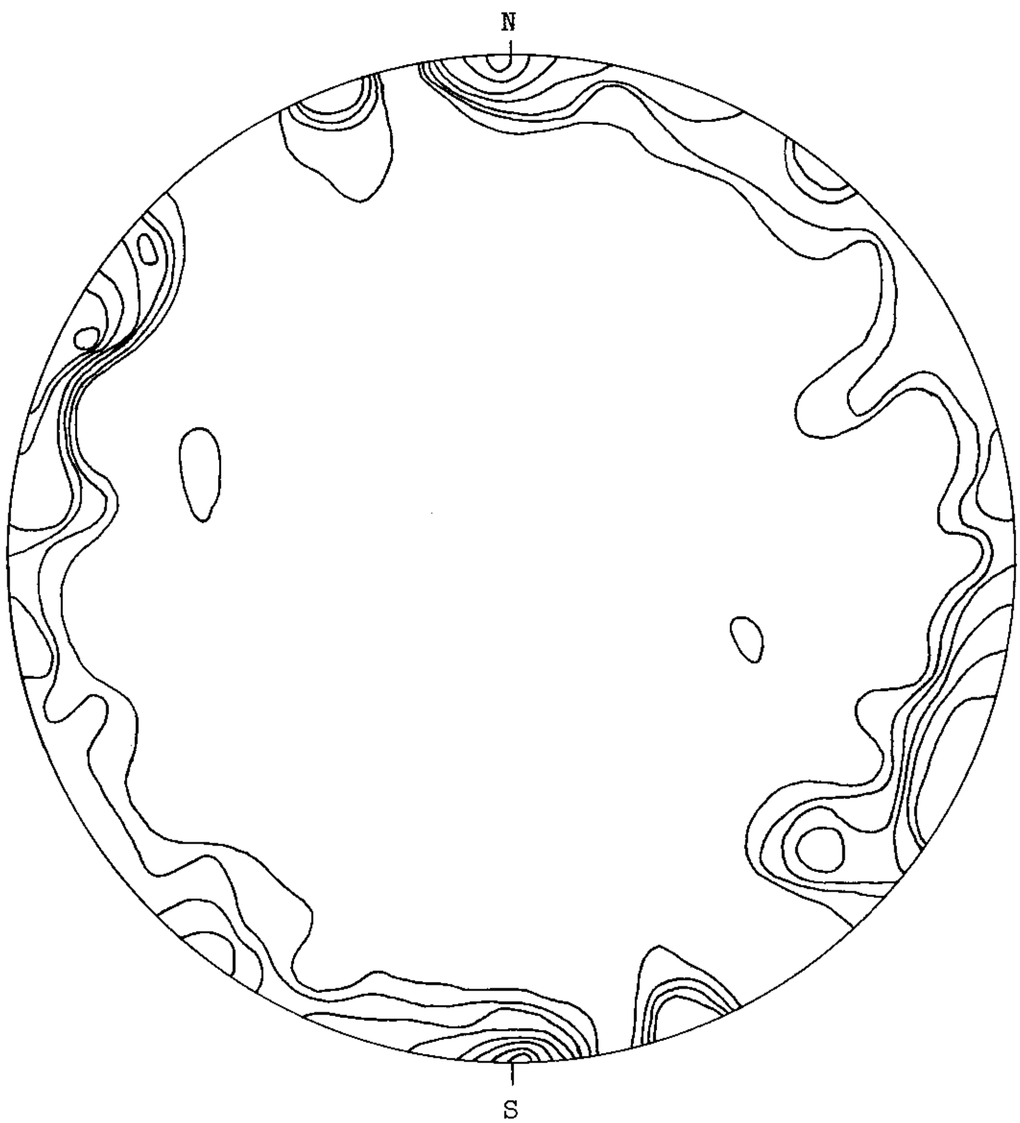
Contour diagram of extensional fractures in the Arnold River Formation southeast of the Chain of Ponds Pluton. Contours represent 7.7, 15.4 and 23.1% of the 13 measurements.

FIGURE 5C



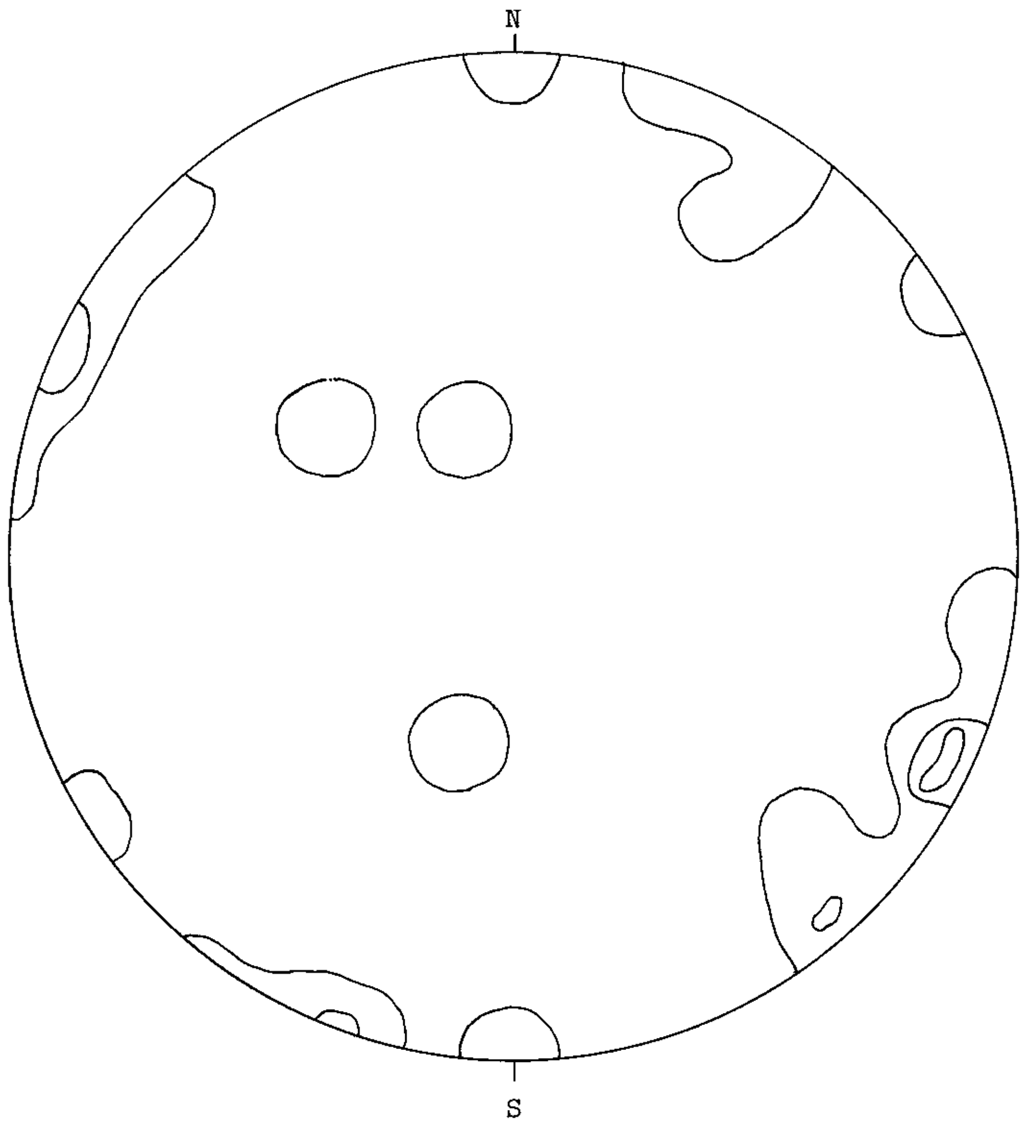
Contour diagram of compressional fractures in the Arnold River Formation southeast of the Chain of Ponds Pluton. Contours represent 7.7 and 15.4% of the 13 measurements.

FIGURE 6A



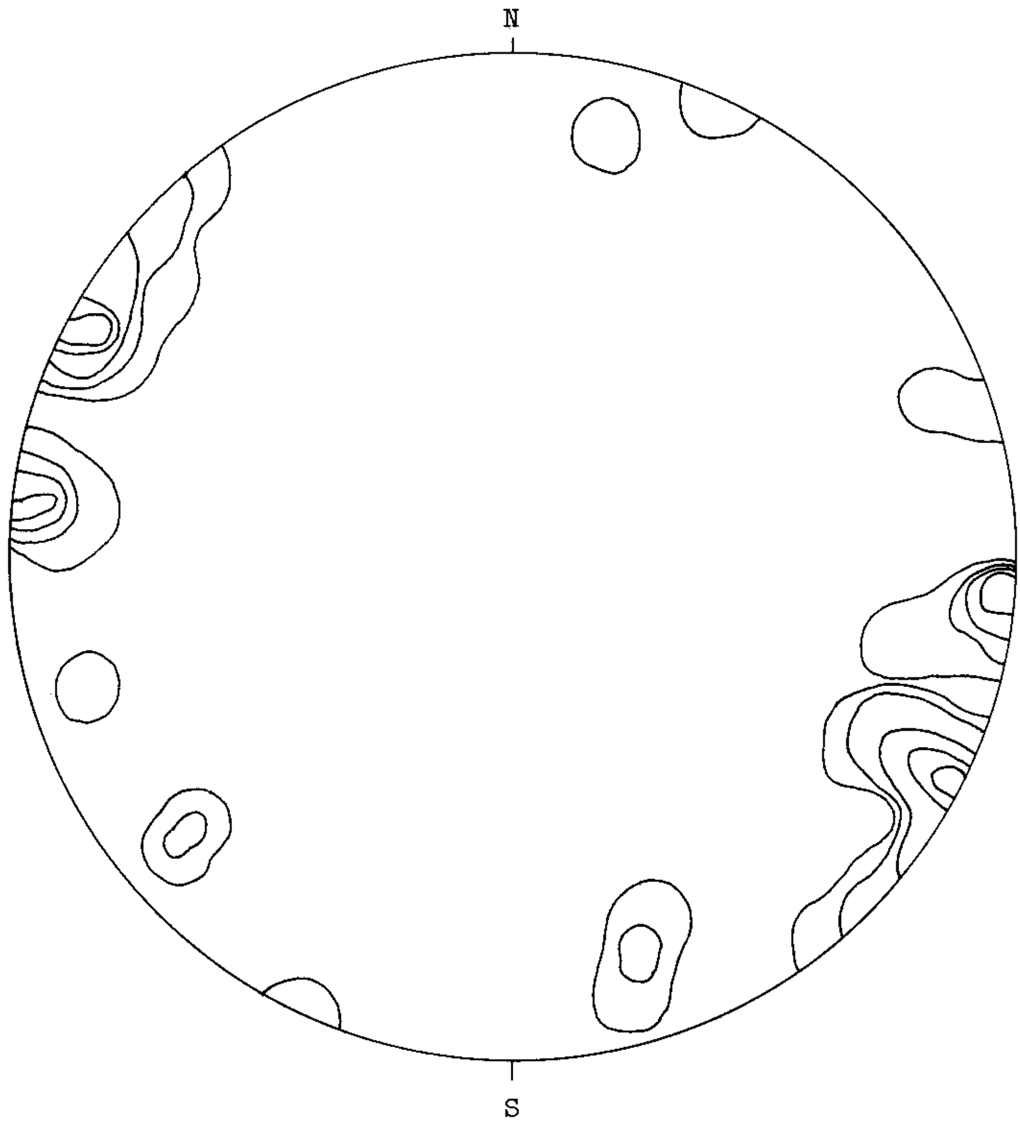
Contour diagram of smooth brittle fractures in the Arnold River Formation east of the Chain of Ponds Pluton. Contours represent 1.7, 2.6, 3.4, 4.3, 7.8, 10.3 and 12.9% of the 116 measurements.

FIGURE 6B



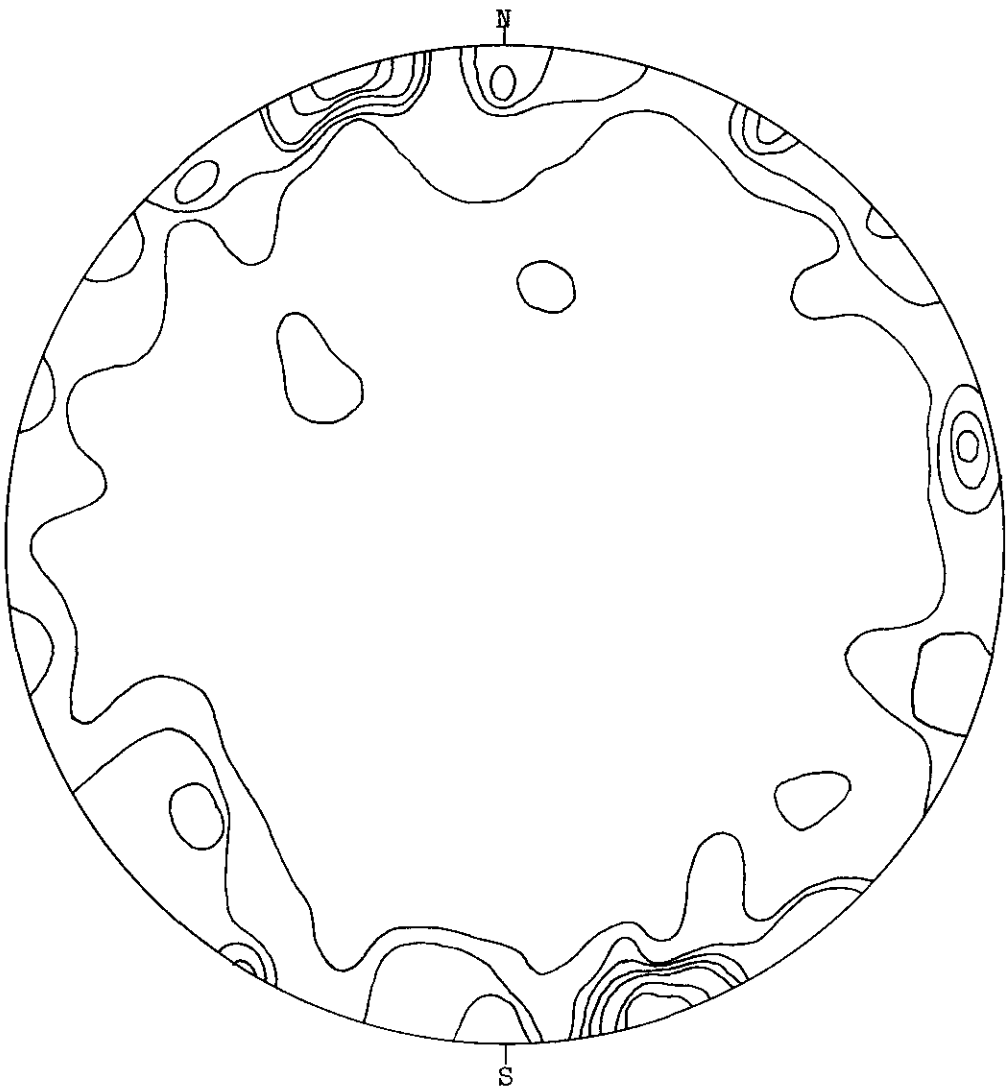
Contour diagram of extensional fractures in the Arnold River Formation east of the Chain of Ponds Pluton. Contours represent 5.9, 11.8 and 17.6% of the 17 measurements.

FIGURE 6C



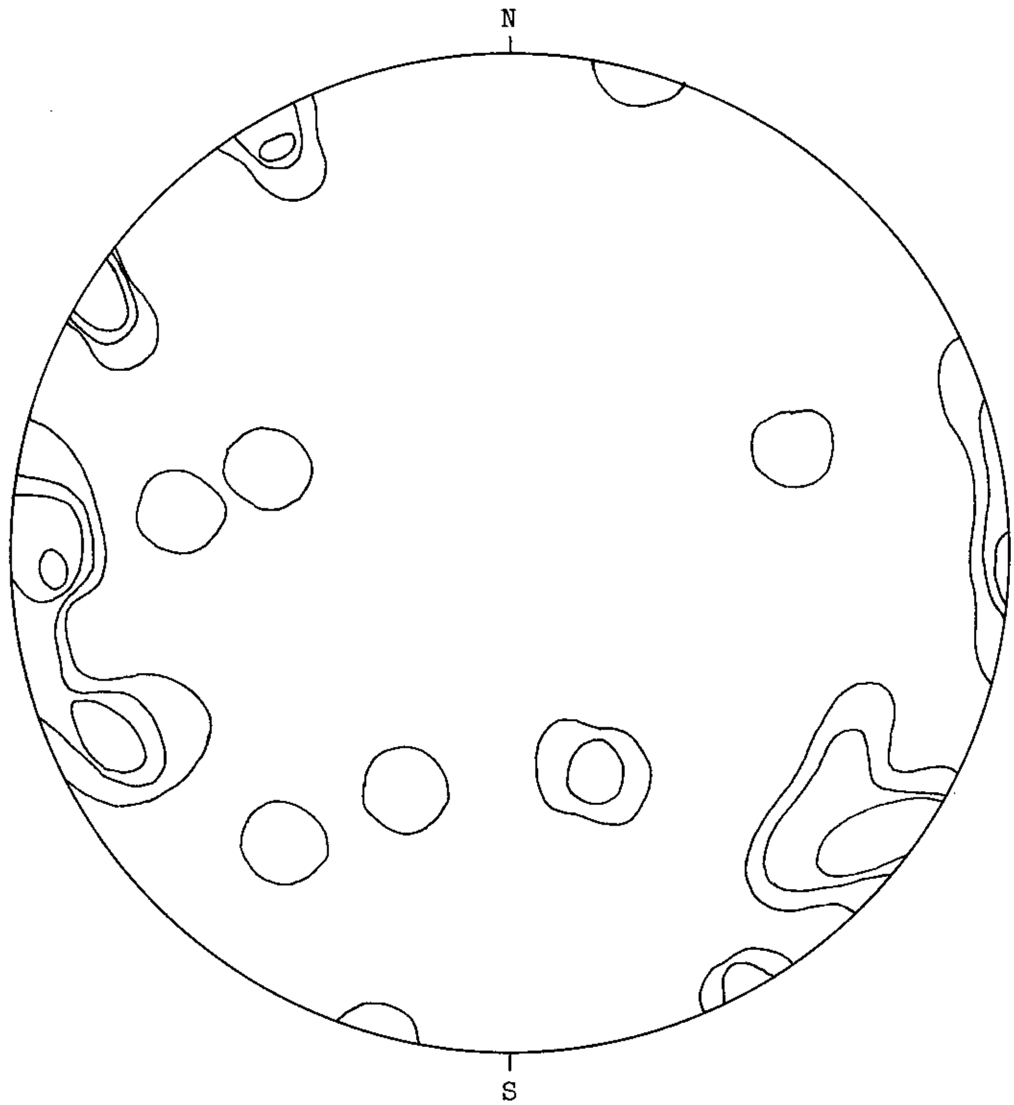
Contour diagram of compressional fractures in the Arnold River Formation east of the Chain of Ponds Pluton. Contours represent 4, 8, 12, 16 and 20% of the 25 measurements.

FIGURE 7A



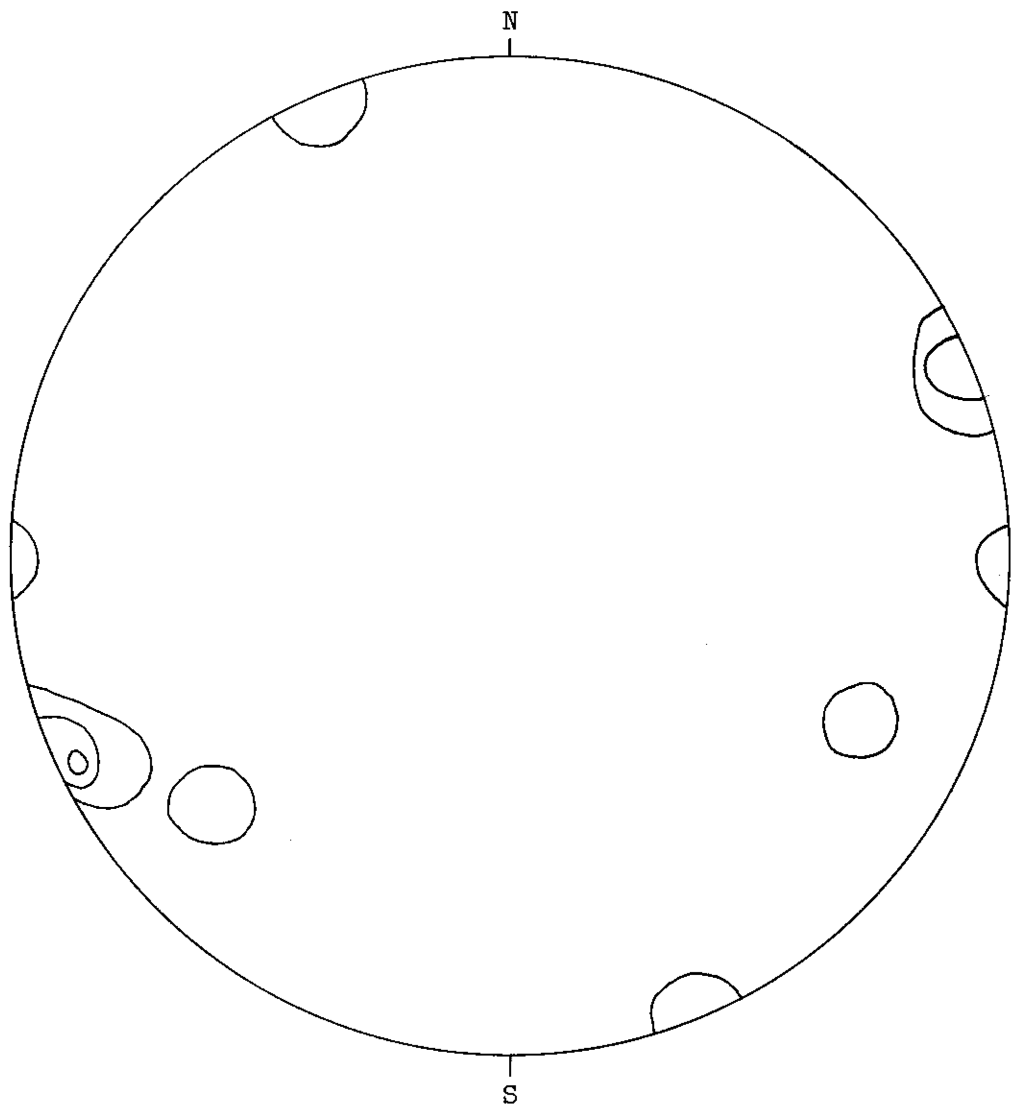
Contour diagram of smooth brittle fractures in the Arnold River Formation north-northeast of the Chain of Ponds Pluton. Contours represent 0.7, 1.4, 2.8, 4.3, 5.7, 7.1 and 8.5% of the 141 measurements.

FIGURE 7B



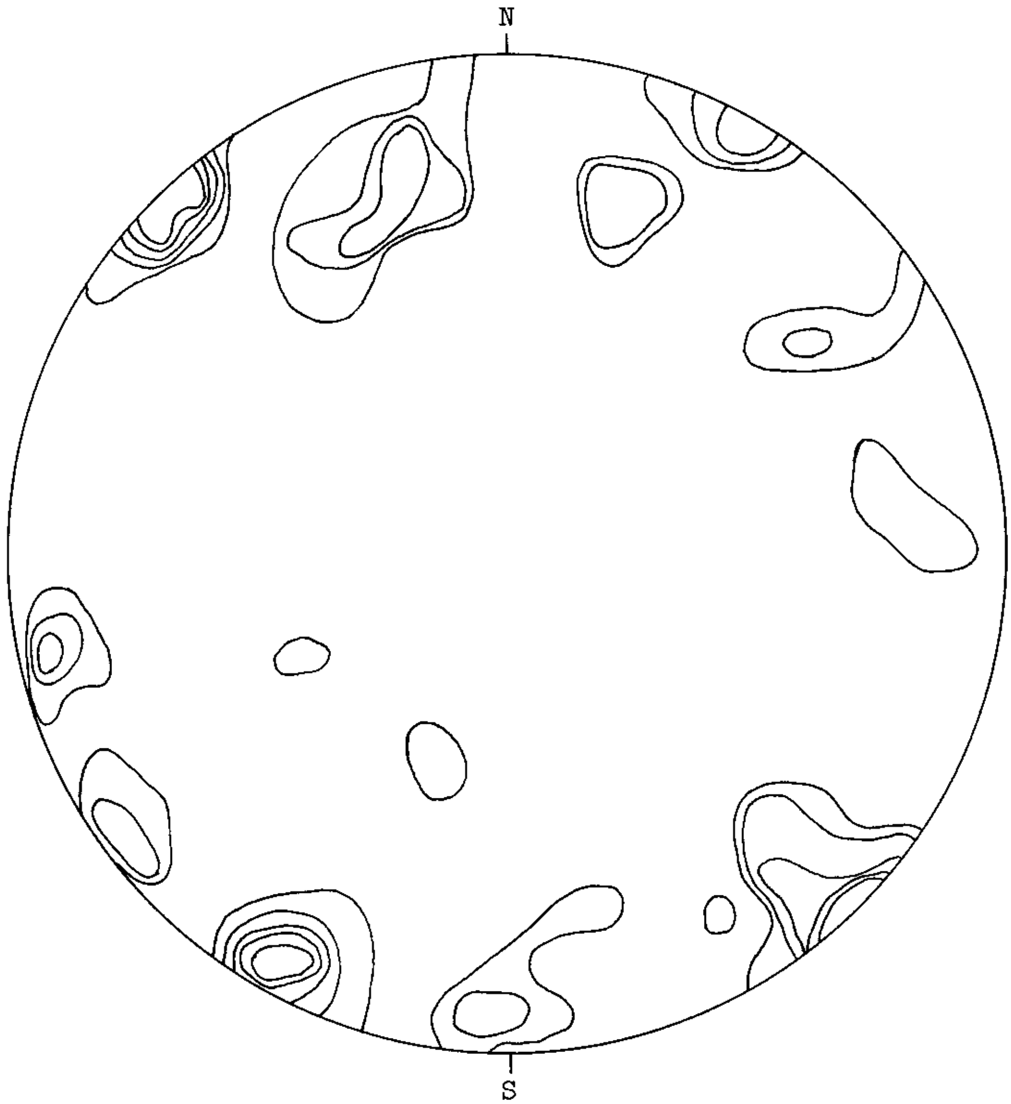
Contour diagram of extensional fractures in the Arnold River Formation north-northeast of the Chain of Ponds Pluton. Contours represent 3.4, 6.9, 10.3 and 13.8% of the 29 measurements.

FIGURE 7C



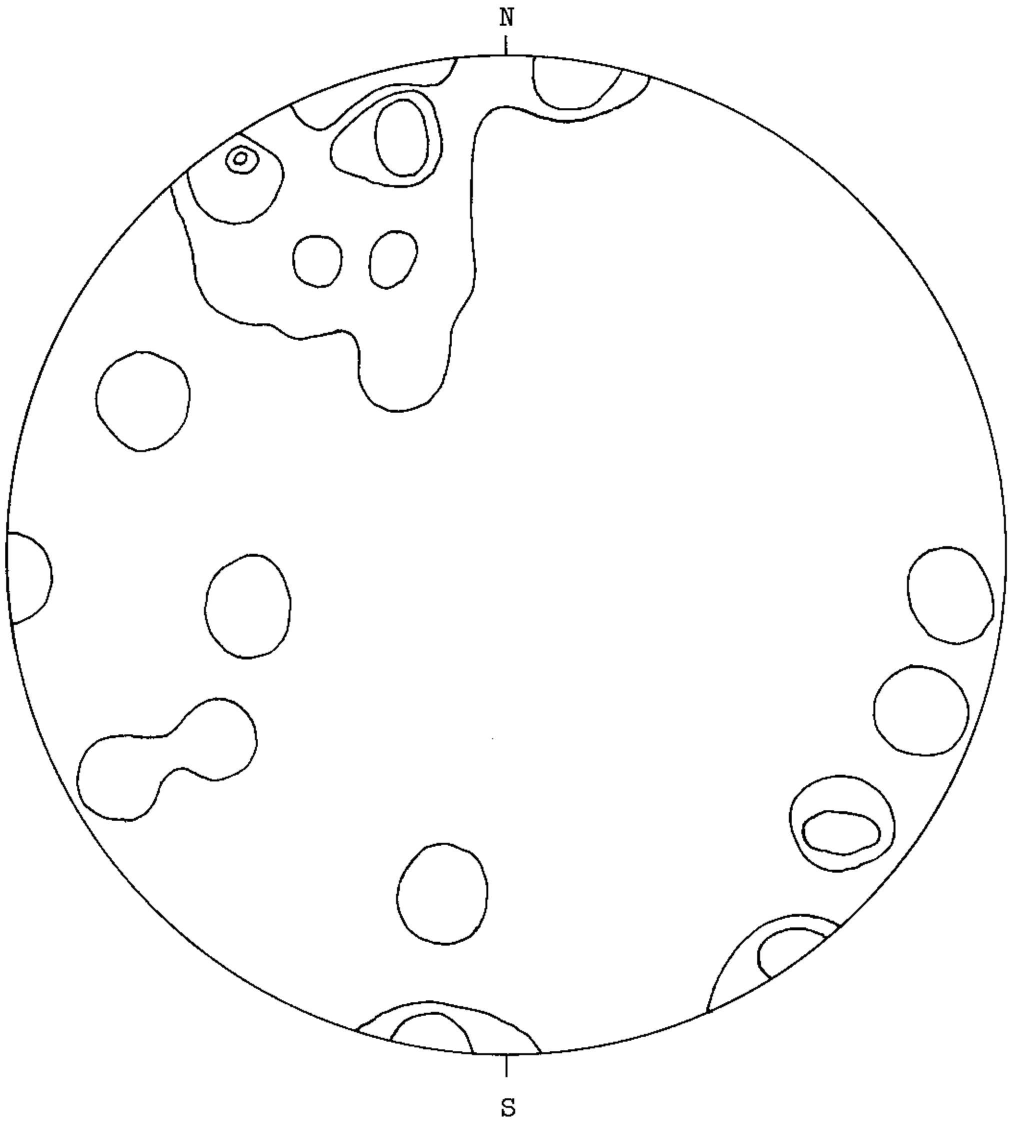
Contour diagram of compressional fractures in the Arnold River Formation north-northeast of the Chain of Ponds Pluton. Contours represent 14.3, 28.6 and 42.9% of the 7 measurements.

FIGURE 8A



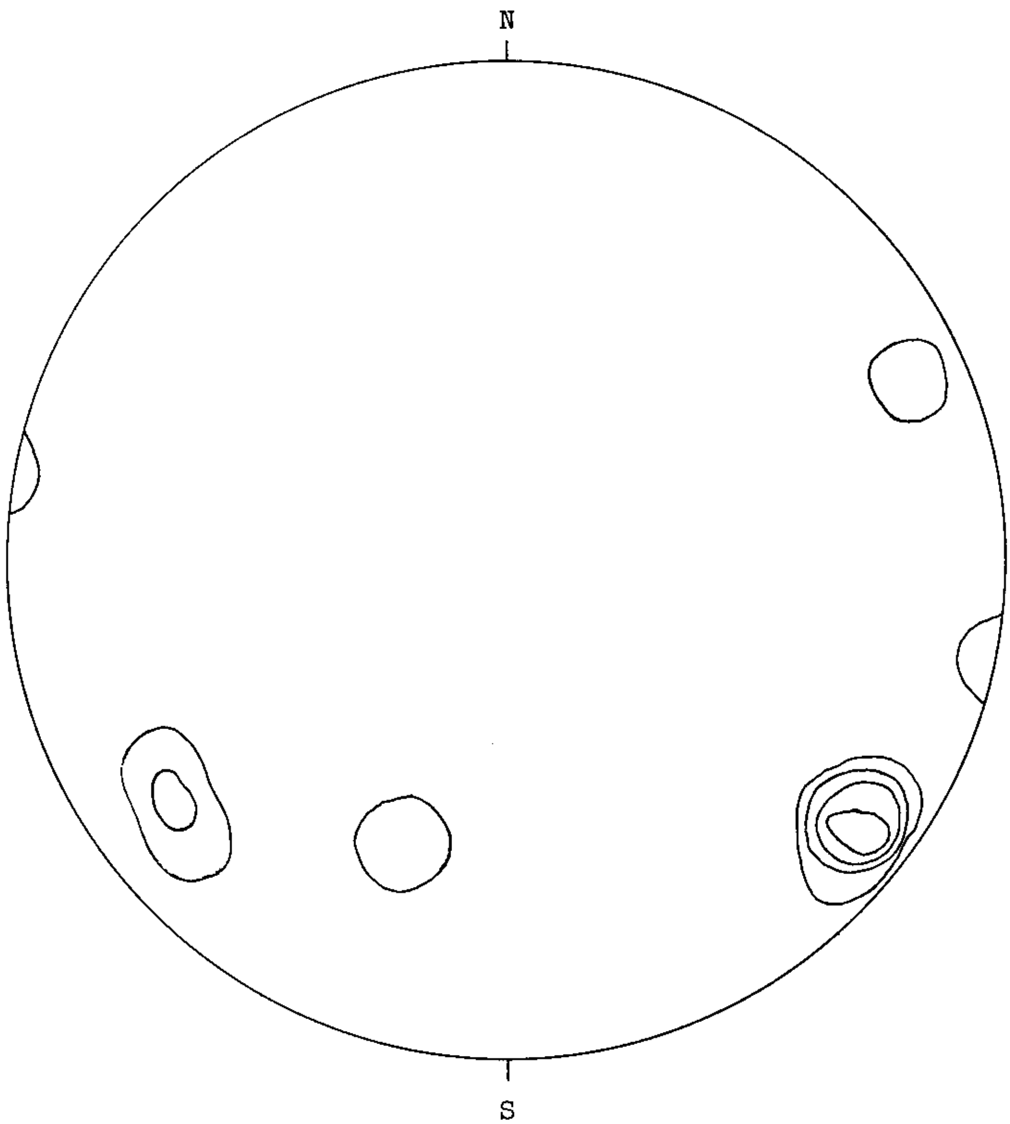
Contour diagram of smooth brittle fractures in the Arnold River Formation northwest of the Chain of Ponds Pluton. Contours represent 2.7, 4.1, 5.4, 6.8 and 8.1% of the 74 measurements.

FIGURE 8B



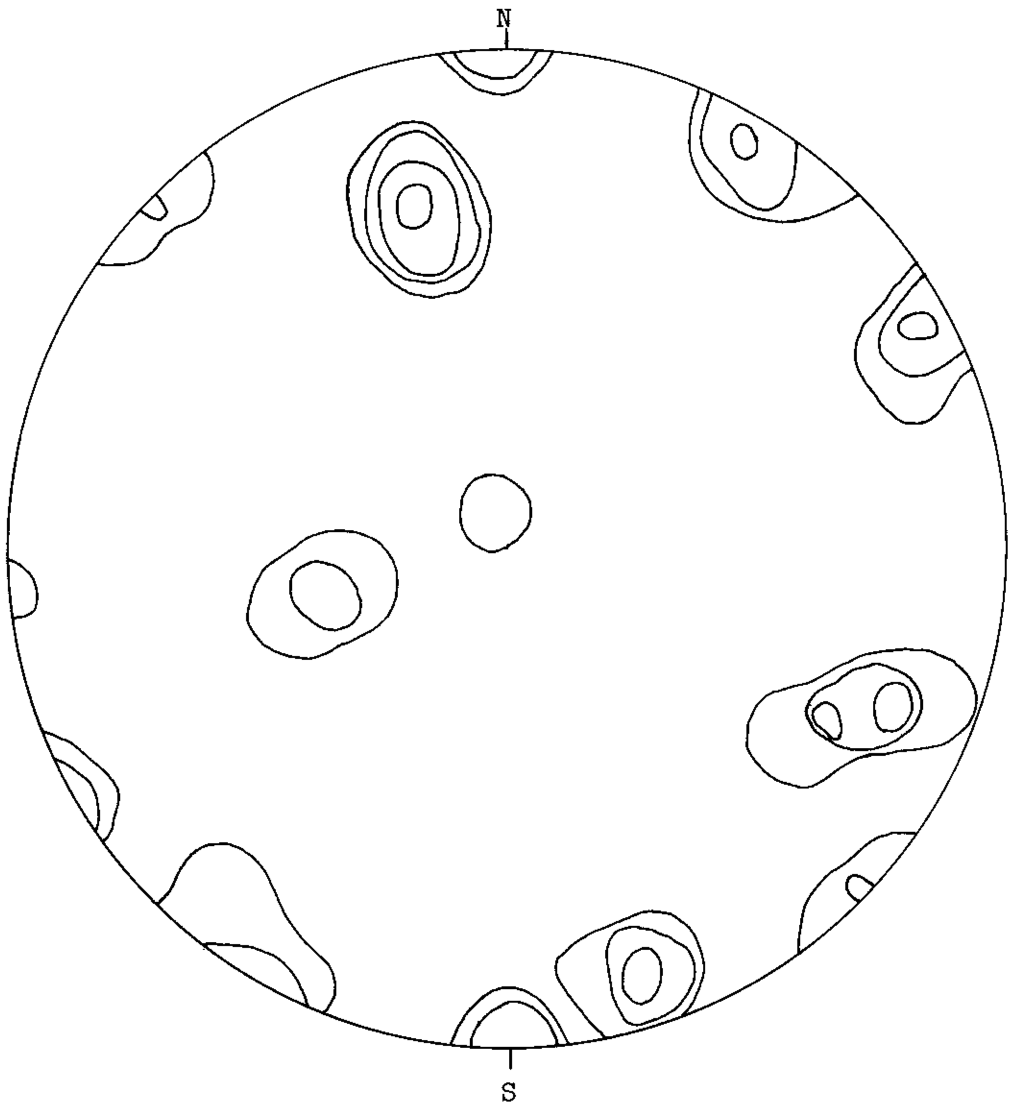
Contour diagram of extensional fractures in the Arnold River Formation northwest of the Chain of Ponds Pluton. Contours represent 3.7, 7.4, 11.1 and 14.8% of the 27 measurements.

FIGURE 8C



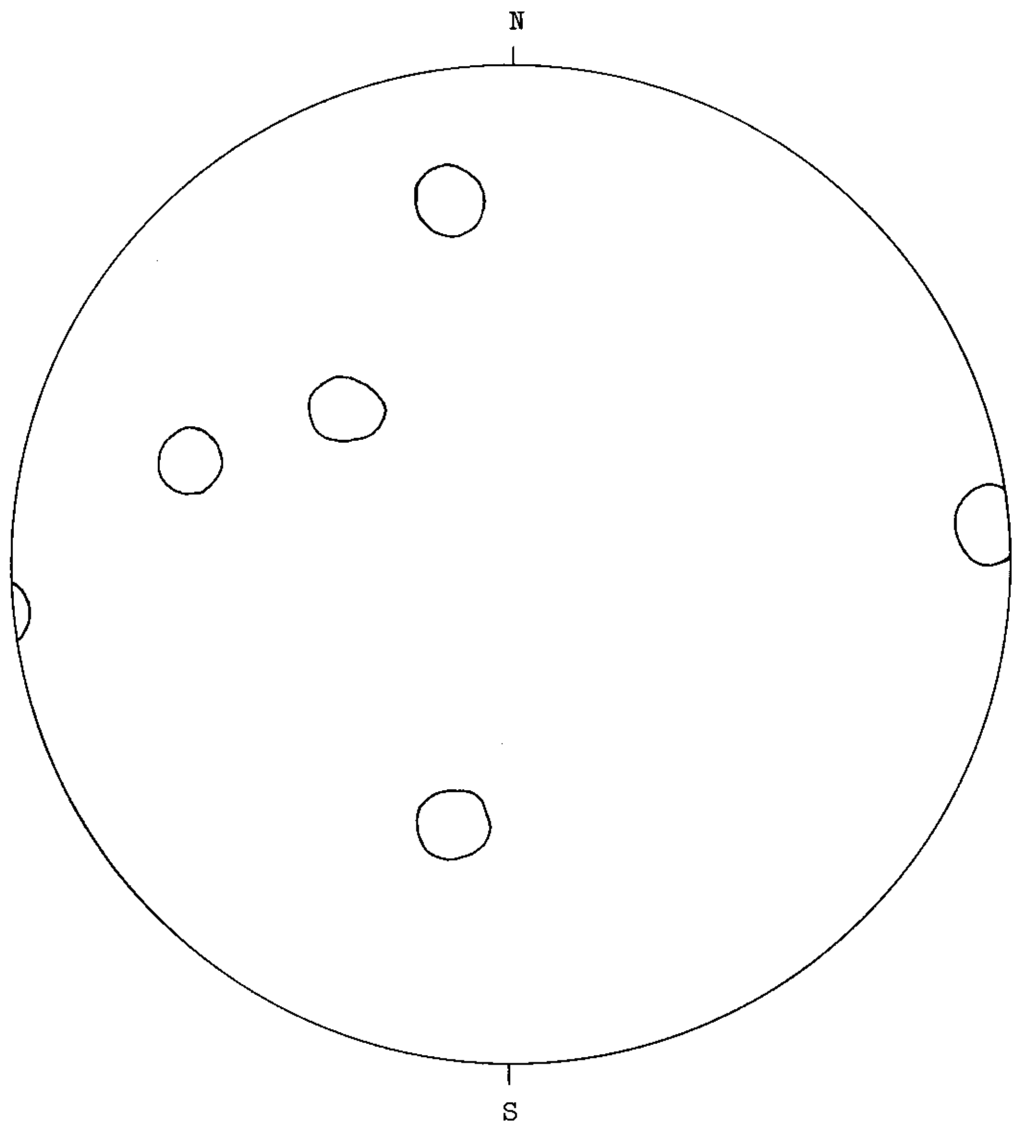
Contour diagram of compressional fractures in the Arnold River Formation northwest of the Chain of Ponds Pluton. Contours represent 11.1, 22.2, 33.3 and 44.4% of the 9 measurements.

FIGURE 9A



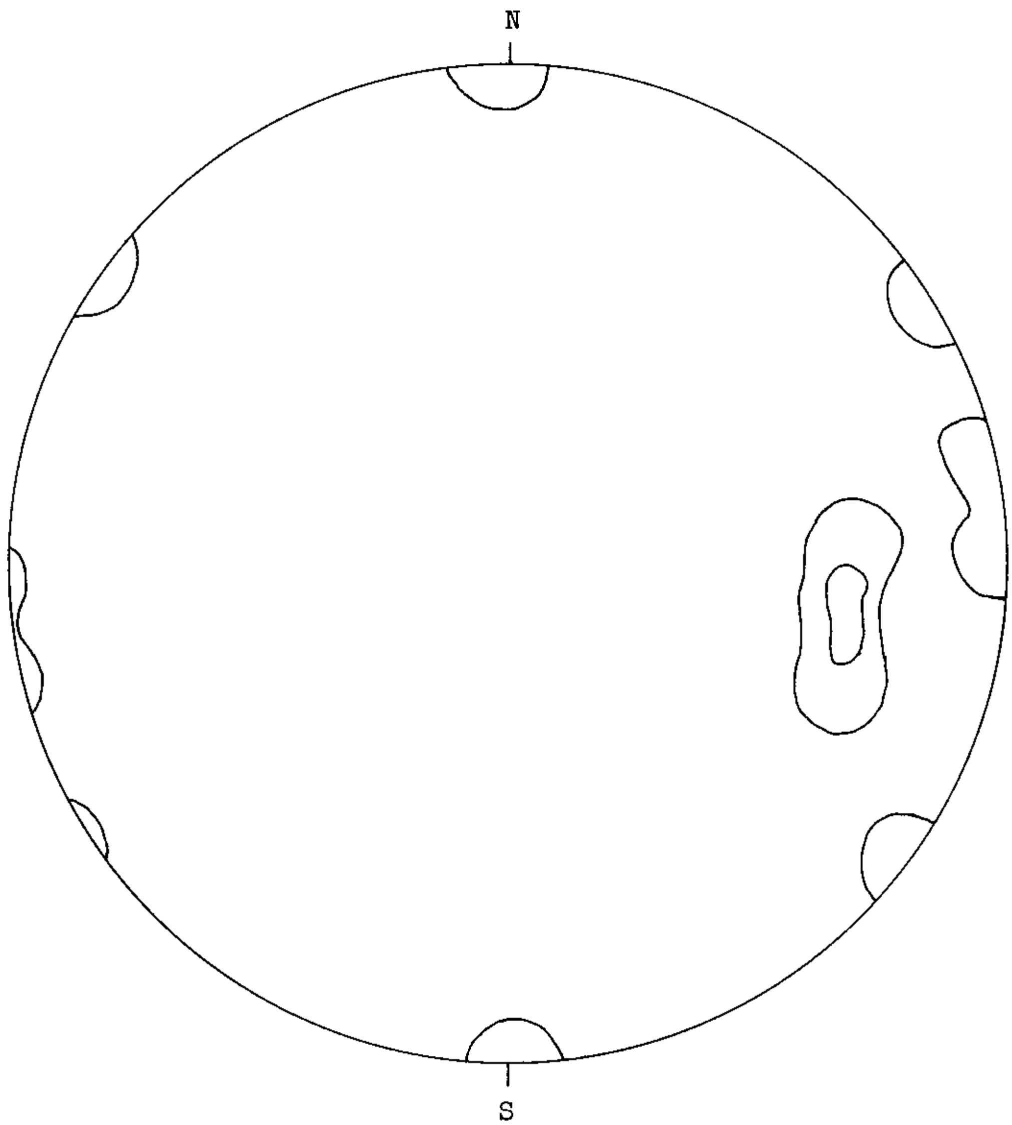
Contour diagram of smooth brittle fractures in the Arnold River Formation west of the Chain of Ponds Pluton. Contours represent 3.7, 7.4, 11.1, 14.8 and 18.5% of the 27 measurements.

FIGURE 9B



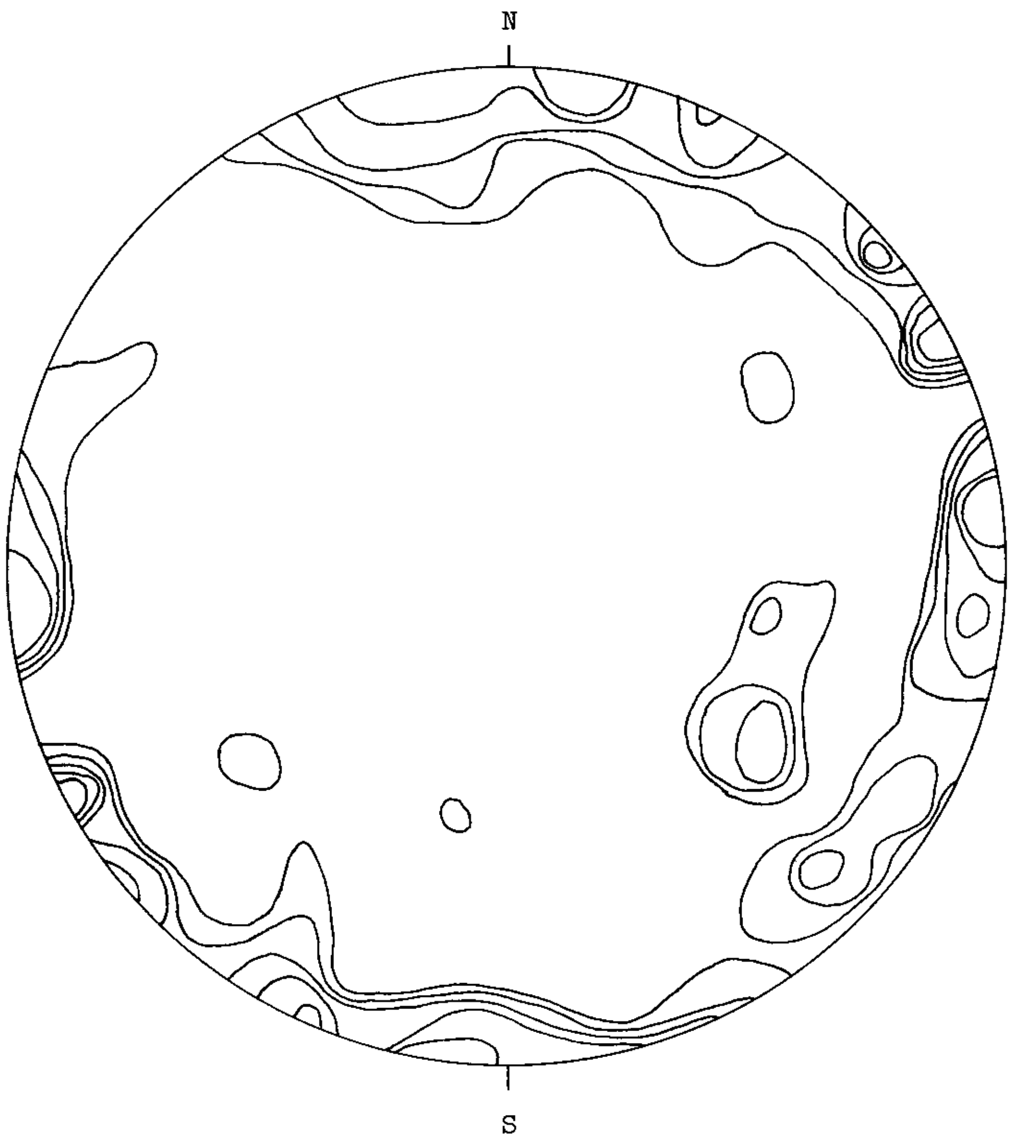
Contour diagram of extensional fractures in the Arnold River Formation west of the Chain of Ponds Pluton. Contours represent 20% of the 5 measurements.

FIGURE 9C



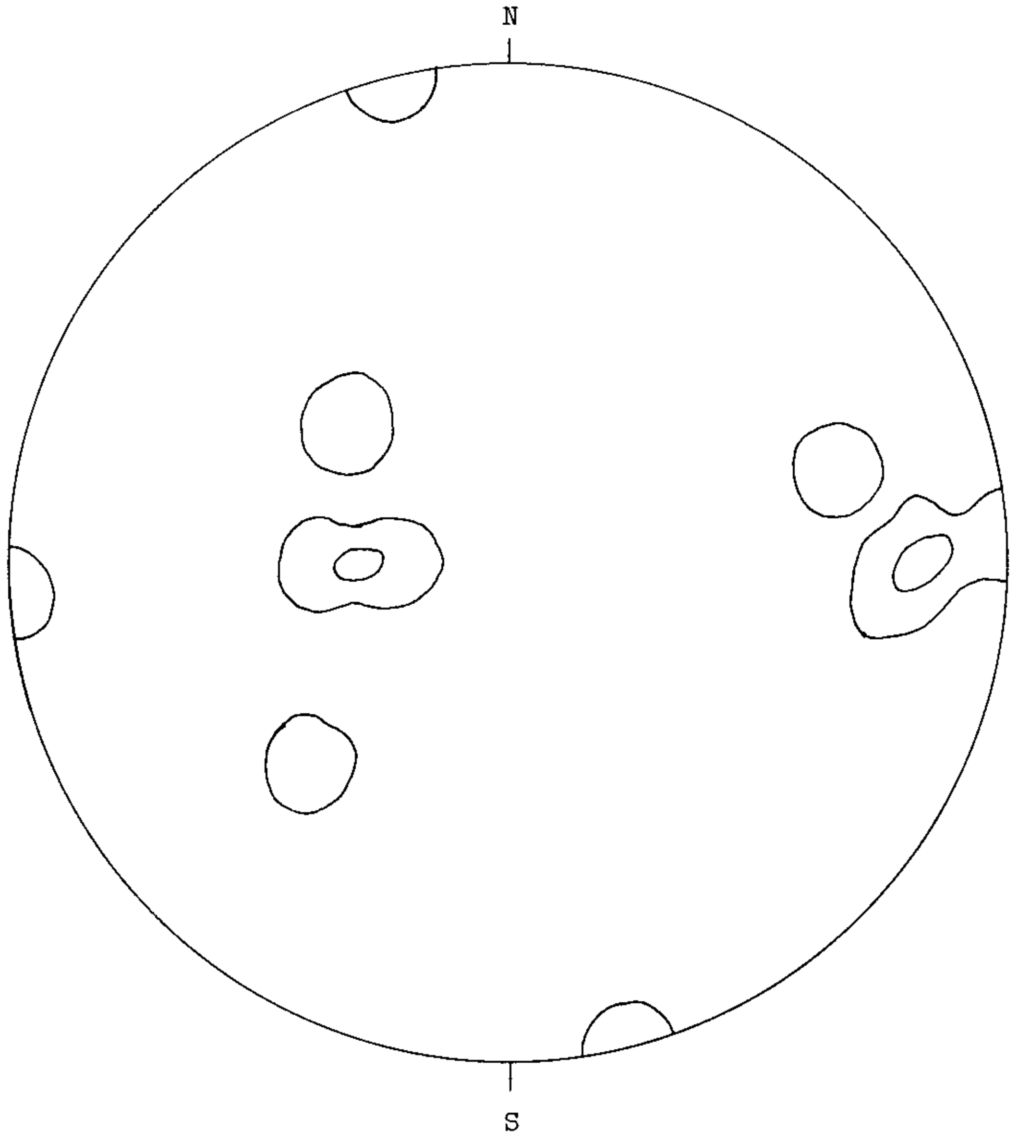
Contour diagram of compressional fractures in the Arnold River Formation west of the Chain of Ponds Pluton. Contours represent 12.5 and 25% of the 8 measurements.

FIGURE 10A



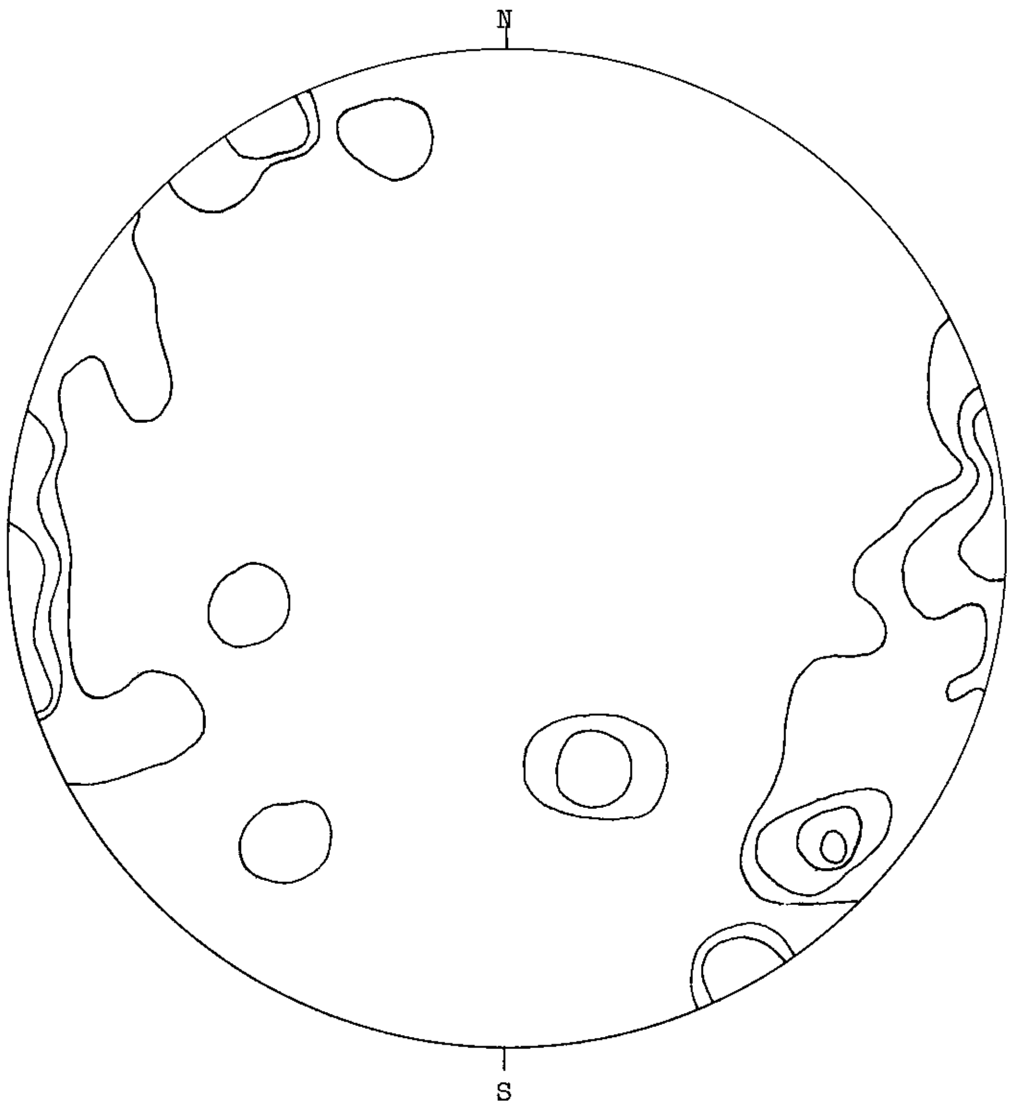
Contour diagram of smooth brittle fractures in the Arnold River Formation southwest of the Chain of Ponds Pluton. Contours represent 1.8, 2.7, 3.6, 4.5 and 5.4% of the 112 measurements.

FIGURE 10B



Contour diagram of extensional fractures in the Arnold River Formation southwest of the Chain of Ponds Pluton. Contours represent 11.1 and 22.2% of the 9 measurements.

FIGURE 11



Contour diagram of dikes in the Arnold River Formation surrounding the Chain of Ponds Pluton. Contours represent 3.3, 6.7, 10.0 and 13.3% of the 30 measurements.

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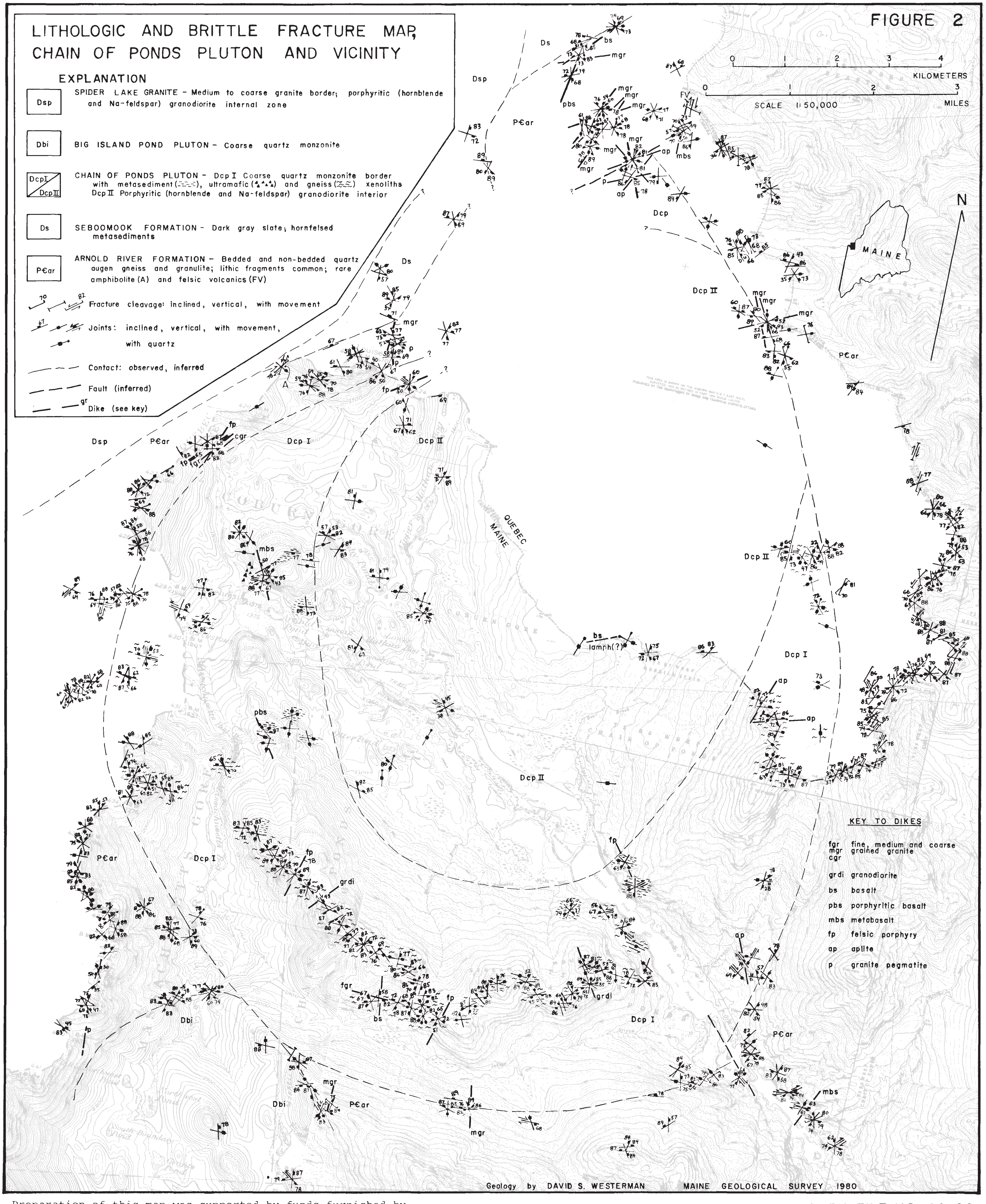

Preparation of this map was supported by funds furnished by the Nuclear Regulatory Commission Grant No. NRC-04-76-291 and the Maine Geological Survey.

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