K/AR AGES AND SIGNIFICANCE OF MAFIC ROCKS, SABINE PENINSULA, MELVILLE ISLAND, DISTRICT OF FRANKLIN

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Abstract

A gabbro dyke, cutting Carboniferous rocks at southern Sabine Peninsula, Melville Island, yielded a K/Ar age of about 123 Ma. Samples of gabbro sills, cutting Permian rocks deep in the Panarctic et al. Drake Point D-68 well, yielded K/Ar ages of about 131 Ma and 152 Ma.

The age of the dyke is broadly contemporaneous with an important unconformity at the margin of Sverdrup Basin, between Cretaceous and Jurassic rocks. The sills may be broadly contemporaneous with phases of crustal subsidence and marine transgression in Sverdrup Basin.

Introduction

Three samples of mafic igneous rocks from Sabine Peninsula, Melville Island, were dated by the K/Ar method (whole rock analysis) by Geochron Laboratories Division (Krueger Enterprises, Cambridge, Massachusetts). One sample was collected from a dyke that cuts surface rocks at Tingmisut Lake; the other two samples are from deep levels in the Panarctic et al. Drake Point D-68 well (Fig. 7.1).

Tozer and Thorsteinsson (1964) mapped the surface rocks of Sabine Peninsula. Upper Paleozoic, Mesozoic, and lower Tertiary rocks of Sverdrup Basin rest unconformably on folded Devonian and older rocks (Fig. 7.1). The Sverdrup Basin succession dips regionally northward, and is interrupted on northern Sabine Peninsula by circular diapirs composed of Carboniferous evaporites. Across the southern part of the peninsula, Lower Cretaceous sandstones (Isachsen Formation) lie on progressively older Jurassic strata eastward, above a low-angle unconformity.

Basalt flows, and dykes and sills ranging in composition from olivine-bearing gabbro to quartz diorite are important constituents of Carboniferous to Upper Cretaceous rocks in Sverdrup Basin, Queen Elizabeth Islands (Blackadar, 1964; Thorsteinsson and Tozer, 1970; Balkwill, 1978). The flows and intrusive bodies are intercalated with and transect Sverdrup Basin sedimentary rocks systematically: the mafic rocks are stratigraphically highest in the succession in the axial part of the basin, where the sedimentary succession is thickest, and are at progressively lower stratigraphic levels toward the basin margins, where the succession is much thinner. The oldest mafic rocks are Carboniferous basalts at northern Axel Heiberg Island (Thorsteinsson, 1974); the youngest are Upper Cretaceous (probably Turonian) basalts at western Axel Heiberg Island (Souther, 1963). Between those lowest and highest levels there are abundant basalt flows and sills and dykes. The isotopic ages of mafic intrusive rocks are known to range from about 190 Ma to about 86 Ma (Balkwill, 1978). From this, it is evident that mafic activity played a long lasting, regionally significant role in the crustal mechanics of basin evolution. Furthermore, levels of organic metamorphism were raised locally in country rocks adjacent to mafic intrusive bodies, affecting generation of hydrocarbons (Powell, 1978).

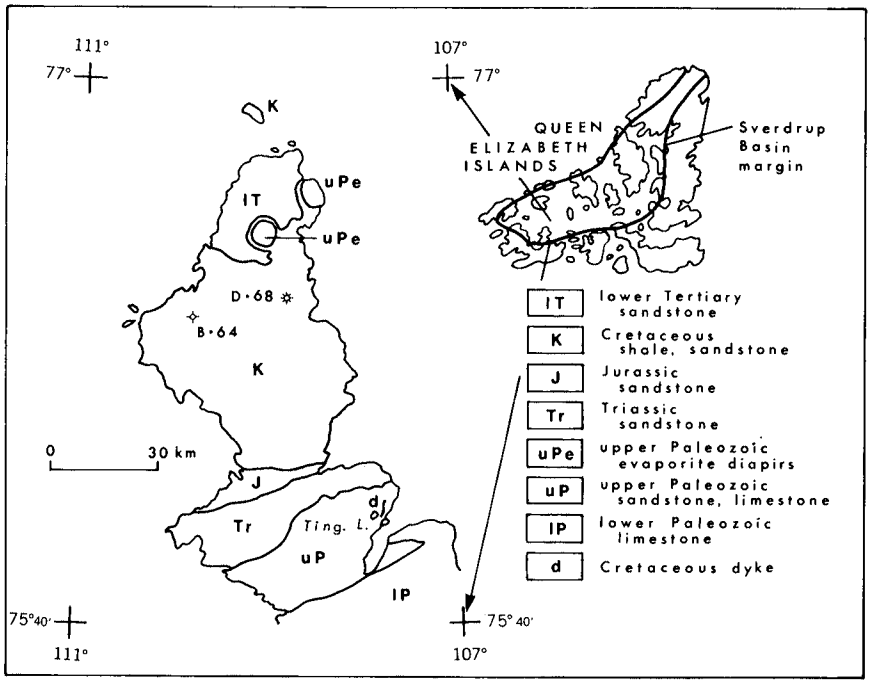

Figure 7.1

Geological setting, Sabine Peninsula, Melville Island. Details of geology are provided by Tozer and Thorsteinsson (1964).

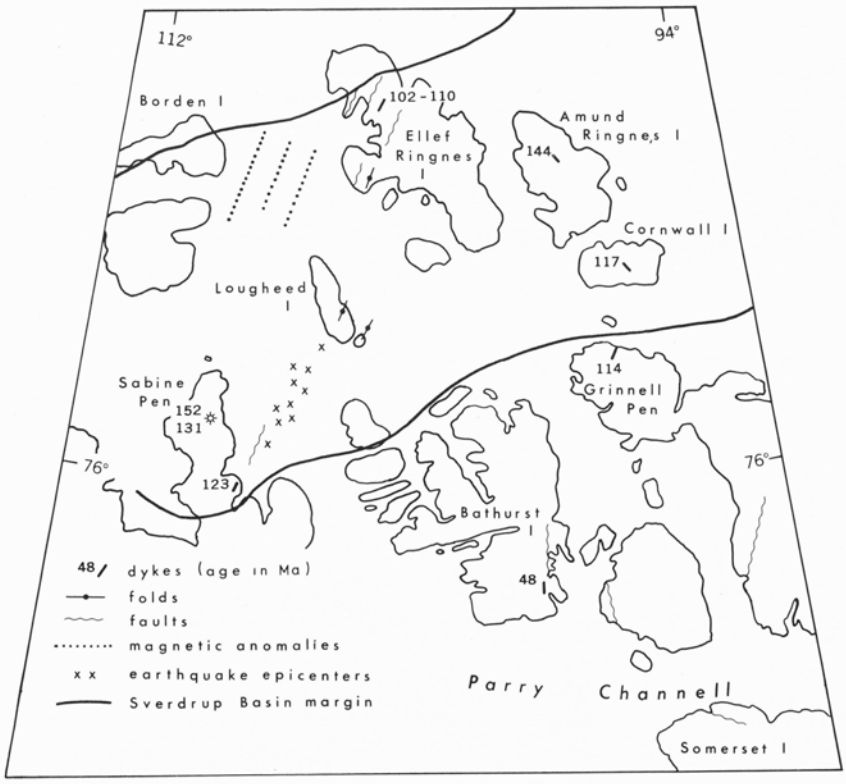

Figure 7.2

West-central Queen Elizabeth Islands, showing northeast-striking structures of Sverdrup Basin, structures of Eurekan Rifting Episode (after Kerr, 1977), and approximate age of mafic intrusions.

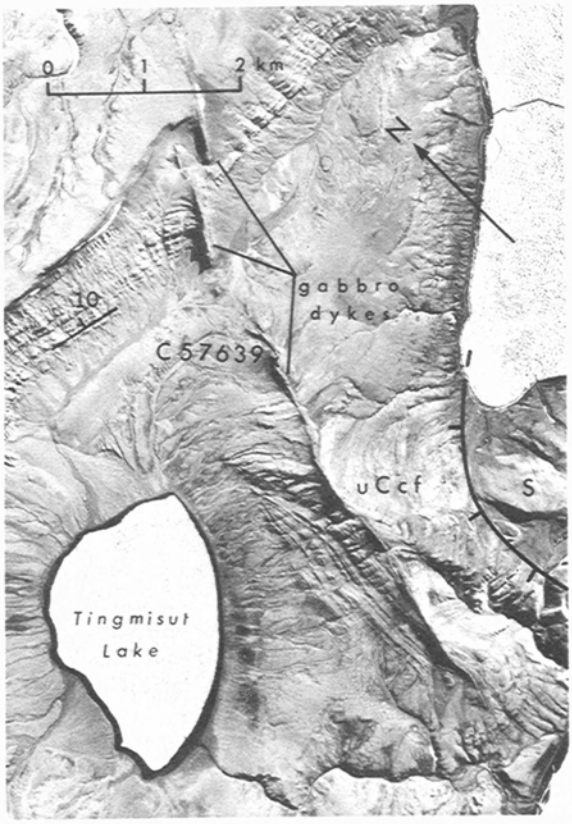

Figure 7.3. Vertical air photo of Tingmisut Lake mafic dykes (part of N.A.P.L. photo A16763-54). uPcf: Canyon Fiord Formation; S: Silurian dolomite; C-57639: sample location.

Not far south of the Sverdrup Basin margin, on eastern Bathurst Island (Fig. 7.2), there is a Maastrichtian basalt flow and some mafic dykes that have been dated isotopically at 48 Ma and 60 Ma (Eocene and Paleocene) (Kerr, 1974). No mafic rocks as young have been proven to be present in Sverdrup Basin, but the dyke at Tingmisut Lake was undated until now, so it has been uncertain whether it is related to the Sverdrup Basin assemblage of intrusions, or to the younger mafic rocks at Bathurst Island.

Mafic Igneous Rocks at Sabine Peninsula

Mafic igneous rocks outcrop at three localities on Sabine Peninsula (Tozer and Thorsteinsson, 1964). There are masses of gabbro — some of which may be ring dykes — in each of the two large circular evaporite piercement domes near the northern coast of the peninsula, and a northeast-striking system of dykes that cut slightly tilted, Carboniferous sedimentary rocks near Tingmisut Lake (Fig. 7.1).

Slightly sinuous dykes at Tingmisut Lake strike N20°E (Fig. 7.3). The largest dyke is about 50 m wide and 4 km long. Two small dykes lie northeastward of the large dyke and strike parallel to it. The dyke rocks are moderately jointed, lying partly as resistant felsenmeer piles at the surface. The rocks are dark green-grey and coarsely crystalline. Blackadar (in Tozer and Thorsteinsson, 1964, p. 173) determined that the large Tingmisut dyke has a subophitic texture, and on the basis of plagioclase composition is a gabbro. The rocks contain as much as 10 per cent titaniferous magnetite. The dykes cut red, orange, and buff quartz sandstones of the Canyon Fiord Formation, which at Sabine Peninsula contain Late Carboniferous fossils. In an irregular zone, a few metres wide, the sandstones are bleached light grey-buff and are cemented by quartz. Canyon Fiord sandstones are part of a northward-dipping homocline, interrupted east of Tingmisut Lake by a normal fault across which Silurian dolomite is juxtaposed against the Carboniferous rocks.

The two sills in the Drake Point D-68 well are similar in gross composition. Both are composed of feldspar, quartz, amphibole, chlorite, titaniferous magnetite and biotite. Their average compositions are more similar than the internal variations with either of the sills. The sills are unusual in that quartz constitutes a relatively high proportion of the total rock. The quartz content varies from 8 to 25 per cent with the greater abundance occurring in the upper half of the sills. The feldspar content is fairly constant throughout the sills with the original feldspar content varying between 40 and 50 per cent. This proportion is now reduced due to intense sericitization throughout all the feldspars. Determinations by X-ray indicate that the mafic minerals in the sills are predominantly amphibole and chlorite with illite reflecting the sericitization of the feldspar. The amphibole content varies inversely with the quartz content and ranges between 10 and 20 per cent. The amphibole content is greater in the lower half of both sills. The chlorite content is relatively uniform: between 10 and 12 per cent, possibly increasing to 15 per cent near the margins of the sills. Biotite occurs in places within the thin-sectioned chip samples and may constitute 3 to 5 per cent of individual chips. An opaque mineral, probably titaniferous magnetite, constitutes the remaining 5 to 12 per cent of the rock.

From their present composition the sills are classified as diorite to quartz diorite. Because of the extensive alteration of the sills, the isotopic ages would have to be considered as minimum ages even though most of the alteration appears to have occurred during the emplacement and crystallization of the sills.

K/Ar Ages

Sample C-57639, collected at the north end of large Tingmisut Lake dyke (Fig. 7.3), yielded an isotopic age of 123 ± 6 Ma.

Panarctic et al. Drake Point D-68 is the deepest well drilled at Sabine Peninsula (T.D. 5415 m, 17 766 ft). Two mafic sills were penetrated in the Lower Permian succession of strata in the D-68 well: between 4682 and 4767 m (15 360-15 640 ft), and between 4883 and 4945 m (16 020-16 225 ft).

A sample from the upper sill, collected from a cored interval at 4685 m (15 369.5 ft), yielded an age of 152 ± 6 Ma and sample from the lower sill, collected from drill cuttings between 4929 and 4947 m (16 170-16 230 ft), an age of 131 ± 6 Ma.

The only other mafic intrusive body in Sabine Peninsula wells is present in Lower Permian rocks, between 3397 and 3452 m (11 145-11 325 ft), in the Panarctic Chads Creek B-64 well. That sill has not been dated.

Discussion

Along the southern margin of Sverdrup Basin, Permian and older rocks at Grinnell Peninsula (Fig. 7.2) are cut by a gabbro dyke that yielded a K/Ar age of about 114 Ma (Kerr, 1976), and Triassic rocks at Cornwall Island have abundant dykes and sills from which a 117 Ma K/Ar age was obtained (Balkwill, in press). K/Ar ages of 112 to 110 m.y. (Larochelle et al., 1975) and 144 Ma (Balkwill, in press) have been obtained from other mafic intrusions in the Ringnes Islands. The radiometric ages of the intrusive rocks at Sabine Peninsula indicate that they are part of the widespread, long-lasting Sverdrup Basin assemblage of Mesozoic intrusions and volcanic flows, and are not part of the latest Cretaceous-early Tertiary family of mafic rocks represented at Bathurst Island. The latter seem to be related genetically to a phase of latest Cretaceous-Tertiary graben formation within and adjacent to Parry Channel, which Kerr (1977) called the Eurekan Rifting Episode.

The stratigraphic age of the Tingmisut Lake dyke is approximately Hauterivian. A thick succession of nonmarine sandstones (Isachsen Formation) represents the late Valanginian-Hauterivian-Barremian-early Aptian interval in Sverdrup Basin. Isachsen Formation sandstones (and younger Cretaceous deposits) broadly overstep the basin margins, giving evidence of fundamental re-ordering of tectonic-depositional regimes in mid-Cretaceous (Balkwill, 1978). Basal Isachsen beds beyond Sverdrup Basin margins are locally as young as Barremian. The basal Isachsen beds above the Jurassic rocks at southern Sabine Peninsula are undated, but, from the foregoing regional considerations, they must lie in the interval late Valanginian-Barremian. The time-stratigraphic age of the dyke at Tingmisut Lake (Hauterivian) is therefore broadly contemporaneous with the phase of tilting, differential uplift, and erosion that produced the unconformity beneath the Isachsen Formation at southern Sabine Peninsula.

A narrow array of north-northeastward-striking structural elements is present in western Sverdrup Basin (Fig. 7.2) (Balkwill et al., in press). The array includes the dykes at Tingmisut Lake, some faults cutting Mesozoic and older rocks east of Drake Point, a swarm of recent earthquake epicentres between Sabine Peninsula and Lougheed Island, folds in Cretaceous rocks on Lougheed Island and western Ellef Ringnes Island, and large, linear magnetic anomalies of undetermined origin between Borden Island and Ellef Ringnes Island. If the Tingmisut Lake dyke is as old as its isotopic age suggests, then crustal instability has prevailed since Early Cretaceous (or earlier) time in a zone that strikes across western Sverdrup Basin in a northeastward direction.

The upper and lower sills in Drake Point D-68 have respective stratigraphic ages of approximately Oxfordian, and late Berriasian or early Valanginian. The Oxfordian was a time of widespread marine transgression and deposition of dark shales in Sverdrup Basin, as was the early Valanginian; late Berriasian was a time of marine regression at the basin margins. For some other time-stratigraphic intervals, transgressive marine dark shales in the Sverdrup Basin succession are matched, approximately, by phases of mafic intrusion or basaltic volcanism; those relationships suggest that transgression was prompted partly by crustal foundering and enlargement of basin space (Balkwill, 1978).

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