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Constraints from detrital zircon geochronology on the early deformation of the Ross orogen, Transantarctic Mountains, Antarctica

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Summary New ages of detrital zircons constrain the timing of the onset of deformation in the Ross orogen. In the Skelton Glacier area, Skelton Group was deformed before cross-cutting intrusion at 551 Ma. The youngest, significant, age-probability peaks from three samples of Skelton Group are 649 Ma, 684 Ma, and 691 Ma. The 649 Ma peak may be considered the maximum depositional age of Skelton Group, constraining the period of deformation to between 649 Ma and 551 Ma. In the upper Scott Glacier area, La Gorce Formation was deformed prior to cross-cutting intrusion at 526 Ma. The youngest, significant, age-probability peaks from two samples of La Gorce Formation are 581 Ma and 619 Ma. The 581 Ma peak may be considered the maximum depositional age of La Gorce Formation, constraining the period of deformation to between 581 Ma and 526 Ma.

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Introduction

In the decade following the International Geophysical Year (IGY) geologists pushed the limits of reconnaissance mapping throughout the length of the Transantarctic Mountains, resulting in the benchmark publication of the Antarctic Geological Map Folio Series in 1969. By that time the general outline of the geology of the Ross orogen was well established, recognizing periods of tectonism in both the Neoproterozoic and the Cambro-Ordovician.

In the ensuing four decades, our understanding of the evolution of the Ross orogen has become considerably more refined. Revision of the Geological Timescale was critical, with greater constraints on the absolute ages of the Precambrian/Cambrian boundary and the subdivisions of the Cambrian Period, permitting chronologic comparison of fossil-dated sedimentary sequences and magmatic events with fair precision (Landing et al., 1998).

What we know today is that throughout the length of the Transantarctic Mountains, the Ross orogen shows both regional variations and widespread similarities. For example, fossil-dated Early and Middle Cambrian carbonate sequences crop out repeatedly from the Pensacola Mountains to Byrd Glacier (Debrenne and Kruse, 1986; Palmer and Rowell, 1995). The presence of volcanic sequences associated with these carbonates varies regionally, with rare volcanics in the central Transantarctic Mountains, plentiful volcanics in the Queen Maud Mountains, and a moderate amount in the Pensacola Mountains. In contrast, throughout Victoria Land no Cambrian sequences are known to exist. Some marbles do occur, but in the Skelton Glacier area they were folded and then intruded at 551 Ma, precluding a Cambrian correlation (Encarnación and Grunow, 1996; Rowell et al., 1993).

The culminating phase of the Ross orogeny occurred throughout the Transantarctic Mountains with deformation in the Middle-Late Cambrian, and voluminous plutonism during the same time period lasting into the Early Ordovician. By comparison, evidence of the onset of tectonism is not pervasive and would appear to be manifested differently in different regions. Placing constraints on the nature and timing of the early orogenic events is important for our overall understanding of the evolution of the Ross orogenic belt.

In order to constrain the onset of deformation in the Ross orogen, we have undertaken a U-Pb study of detrital zircons from two widespread localities where cross-cutting intrusions provide a lower bound for “early” deformation. The analyses have been done in the Arizona LaserChron Center at the University of Arizona.

Skelton Glacier area

As mentioned above, deformation of Skelton Group occurred prior to intrusion at 551 Ma. An older bound on deformation of Skelton Group was provided loosely by a Sm-Nd mantle separation age, T_{DM} , of 700-800 Ma, obtained from a pillow basalt within the Group (Rowell et al., 1993). In order to further constrain the age of the Skelton Group, we have determined U-Pb dates on detrital zircons from three samples, KCI and KCJ from the Teall Island and KCQ from Red Dog Bluff. The age probability plots of the single-grain ages are shown in Figure 1. Data are available from the authors. The youngest peaks with contributions (at 2 sigma) from three or more analyses are KCI – 684 Ma, KCJ – 691 Ma, and KCQ - 649 Ma. These ages may be taken as the maximum age of deposition of Skelton Group.

Since Skelton Group is known to contain felsic and mafic volcanic rocks (Skinner, 1982), these would be a likely source for the youngest zircons in the samples. It is reasonable to conclude that the young age peaks are close to the

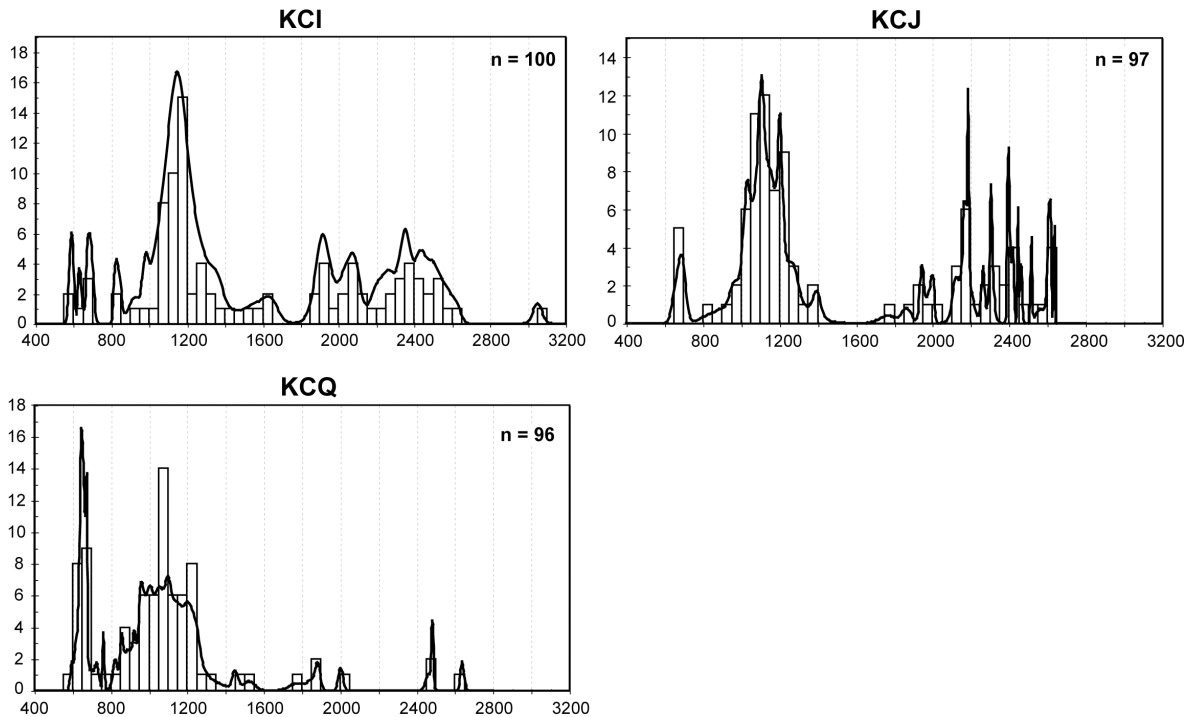


Figure 1. Age-probability plots of detrital zircons from Skelton Group. y-axis = number of grains. x-axis = age (Ma). n = total number of grains analyzed. Significant age-probability peaks were determined using the “Detrital Zircon Age Extractor” macro of the Arizona LaserChron Center. Peaks were chosen where three or more analyses contributed overlap at the 2-sigma level. The age-probability peaks (Ma) are followed in parentheses by the number of analyses contributing to each peak. **KCI:** 684 (3), 929 (7), 983 (12), 1149 (39), 1630 (4), 1918 (9), 2073 (8), 2264 (7), 2353 (7), 2436 (6). **KCJ:** 691 (4), 1032 (17), 1107 (25), 1203 (20), 1262 (10), 1394 (4), 2125 (4), 2168 (6), 2185 (7), 2304 (4), 2395 (4). **KCQ:** 649 (10), 674 (6), 824 (3), 859 (6), 890 (7), 922 (10), 960 (17), 1006 (24), 1055 (24), 1100 (26), 1202 (22).

actual depositional age of the sediments. Although these data shorten the period of time when deformation of Skelton Group was possible (compared to the T_{DM} of 700-800 Ma), there is still approximately 100 m.y. between our youngest detrital zircons and the intruding plutons.

Scott Glacier area

At a locality near the head of Scott Glacier, clastic metasediments of the La Gorce Formation were folded and then intruded by a hypabyssal phase of the Wyatt Formation. When Stump et al. (1986) published these relationships, the Wyatt Formation was considered to be Neoproterozoic in age based on earlier Rb-Sr isochron dates on samples from a scattering of localities from Nilsen Plateau to the Thiel Mountains (Faure et al., 1968, Faure et al., 1979, Stump et al., 1986). More recently, a reliable date on the Wyatt Formation of 526 ± 2 Ma (conventional U-Pb zircon) was obtained on a sample from the northern La Gorce Mountains (Encarnación and Grunow, 1996). A SHRIMP U-Pb study produced a similar age of 527 ± 5 Ma for Wyatt Formation (Vogel et al., 2002). This gives a minimum age for deformation of La Gorce Formation.

Stump et al. (1986) also considered that La Gorce Formation, a graywacke-shale sequence lacking fossils, was correlative with other formations of the Neoproterozoic Beardmore Group (Goldie, Duncan, Party, Patuxent). Goodge et al. (2002) showed that much of what had previously been called Goldie Formation in the Nimrod Glacier area has detrital zircons as young as 520 Ma, requiring a Cambrian age for the sedimentary sequence. Similarly, a younger age for a portion of the Patuxent Formation in the Pensacola Mountains is indicated by a U-Pb zircon date of ~500 Ma from the interbedded Gorecki felsite (Van Schmus et al., 1997). Additionally, a recent study by Goodge et al. (2004) has found detrital zircons as young as 513 Ma in Patuxent Formation.

In light of these revisions to sequences previously considered to be Neoproterozoic, the question of the age of the La Gorce Formation is important as well, especially toward bracketing the timing of its deformation. We analyzed

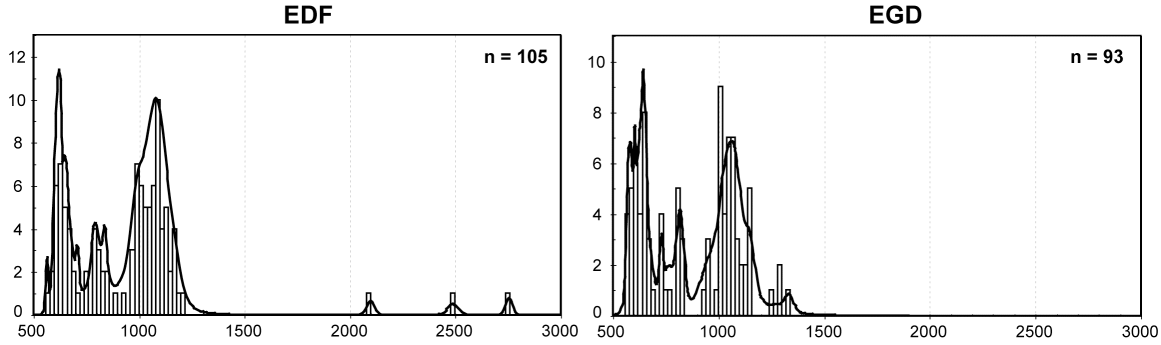


Figure 2. Age-probability plots of detrital zircons from La Gorce Formation. y-axis = number of grains. x-axis = age (Ma). n = total number of grains analyzed. **EDF:** 619 (14), 648 (12), 709 (8), 795 (11), 838 (10), 1081 (45). **EGD:** 581 (12), 605 (10), 628 (15), 647 (13), 732 (5), 764 (7), 820 (9), 1065 (37), 1333 (4).

two samples collected in the La Gorce Mountains on the spur trending northeast from Ackerman Ridge (spot height 2230±). The results are shown in Figure 2. The youngest age probability peaks are 619 Ma for EDF and 581 Ma for EGD. Considering the maximum age of deposition of La Gorce Formation to be 581 Ma, the time between deposition and intrusion of Wyatt Formation was not more than ~55 m.y.

Discussion

When one compares ages of the youngest zircons in Skelton Group and La Gorce Formation (649 Ma versus 581 Ma, respectively), the difference strongly suggests that the depositional age of La Gorce Formation was younger than Skelton Group. When one compares the permissible age ranges between deposition and deformation of Skelton Group and La Gorce Formation (649 Ma to 551 Ma versus 581 to 526 Ma, respectively), it can be seen that the ranges overlap by only about 30 m.y. Although it is possible that deformation occurred within this 30 m.y. window (581-550 Ma), it is more likely that deformation of Skelton Group occurred earlier than deformation of La Gorce Formation. Based on data from these two localities, it appears that the onset of deformation in the Ross orogen was diachronous.

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