Geoscience Canada

1983 Archean Geochemistry and Early Crustal Genesis Field Workshop

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Volume 11, Number 1, March 1984

URI: https://id.erudit.org/iderudit/geocan11_1con01

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Publisher(s)

The Geological Association of Canada

ISSN

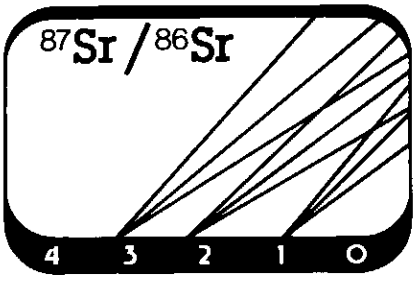
0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this article

Feininger, T. (1984). 1983 Archean Geochemistry and Early Crustal Genesis Field Workshop. *Geoscience Canada*, *11*(1), 47–49.

Conference Reports



1983 Archean Geochemistry and Early Crustal Genesis Field Workshop

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It is proposed that a good part of Canada's upcoming Lithoprobe project will be concentrated on the Kapuskasing structure, a 500 km long curvilinear feature that slices northeastward through the Archean Superior province from the shore of Lake Superior to the Moose River basin near James Bay. The structure was first recognized by Garland (1950) who crossed it on two regional gravity traverses in Northern Ontario. He called attention to a belt of positive Bouguer anomalies (the "Kapuskasing-Fraserdale high") which he attributed to a northeastward-trending band of "thinned granitic layer". Subsequent gravity mapping with appreciably greater station density by Innes (1960) succeeded in outlining most of the structure. Innes suggested that the Kapuskasing-Fraserdale high reflected a major tensional feature of the crust, perhaps not unlike the East African rift zone.

Whereas these early interpretations on the origin of the Kapuskasing structure were based on a tensional tectonic regime, current views lean in the opposite direction, that the structure is a slice of Archean lower continental crust, exposed at the surface by erosion following an episode of obduction. By this interpretation, the Kapuskasing structure exposes a crustal cross section 20 to 25 km thick, with progressively deeper levels laid bare eastward from the Michipicoten greenstone belt of the Wawa area, through the Wawa domal gneiss terrane, to the far edge of the Kapuskasing structure at the Ivanhoe Lake cataclastic zone, interpreted as the westward-dipping detachment surface at the base of the obducted crust (Percival and Card, 1983). The low-grade Abitibi greenstone belt east of the Kapuskasing structure would therefore be correlative with the Michipicoten belt. The progressive increase of metamorphic grade eastward to reach the granulite facies at the Ivanhoe Lake cataclastic zone, quantitatively traced by various mineralogic geobarometers and geothermometers (Percival, 1983), the attitude of basaltic dikes, structural models of Bouguer gravity anomalies, and the lithologic similarity of the Michipicoten and Abitibi greenstone belts all are in keeping with the proposed interpretation (Percival and Card, 1983).

The Kapuskasing structure provided the focus of the 1983 Archean Geochemistry and Early Crustal Genesis Workshop which convened in Ottawa on Wednesday August 10th. Forty-six geoscientists registered from near and far: 24 from the U.S., 16 from Canada, 3 from Australia, and one each from West Germany, the Peoples' Republic of China and Zimbabwe. The workshop was sponsored jointly by the Geological Survey of Canada (GSC), the International Geologic Correlation Project (IGCP), the Lunar and Planetary Institute (LPI), the National Aeronautics and Space Administration (NASA) and the Ontario Geological Survey (OGS).

The workshop was divided into an opening day of 16 formal papers, followed by a six-day, west-to-east field trip across the Kapuskasing structure. The papers dealt with various facets of the origin of Archean crust, although only one dealt with Kapuskasing rocks directly. Expanded abstracts were included with the 70-page field trip guide given to each registrant.

Proceedings got underway in Alice Wilson Hall at the GSC, where the registrants and a roughly equal number of onlookers from the Ottawa geological community were welcomed by Dr. J.G. Fyles (Chief Geologist, GSC). The formal papers began with Jim Wilson (University of Zimbabwe) leading off the morning session with an exposition of Zimbabwean greenstone belts. Dealing with another tropical realm, peninsular India, Kent Condie and Phil Allen (New Mexico Institute of Mining and Technology) discussed and illustrated with beautiful field photos the transition of an Archean granite-greenstone terrane into charnockite. Dave Fountain (University of Wyoming) followed with a discussion of crustal cross sections, using the Ivrea zone of the Italian Alps as his principal example. Werner Weber (Manitoba Geological Services Branch) reported on the relatively felsic Pikwitonei granulite domain, interpreted as a lower crustal level exposed at the far end of the Superior province, 1000 km northwest of the Kapuskasing structure. Lew Ashwal, P. Morgan and W.W. Leslie (LPI) spoke on a mystifying problem of granulite-facies metamorphism: how to carry supracrustal rocks to great depths, heat them to high temperatures, and then reexpose them at the surface, in many places still underlain by normal thicknesses of continental crust. Roberta Rudnick, now at the Australian National University (ANU), Lew Ashwal and Darrell Henry (LPI) showed through fluid inclusions studies that CO_2 was virtually the exclusive fluid phase during granulite-facies metamorphism of rocks in the Kapuskasing structure. Gil Hanson (SUNY, Stony Brook), developed the use of olivine and plagioclase saturation surfaces to place limits on the compositions of cumulate phases and intercumulus melts as well as to define processes of melting in the mantle.

Ross Taylor (ANU) set in motion the afternoon session with an outline of the development of continental crust based chiefly on the distribution of REEs in fine-grained clastic rocks through time. Bob Dymek (Harvard University) J.L. Boak (Arco) and L.P. Gromet (Brown University), followed by Ullrich Rast (Max Planck Institute, West Germany) presented papers

on the chemical evolution of the 3.8 Ga Isua supracrustal rocks in western Greenland. George McGill (University of Massachusetts) then spoke on the tectonic evolution of Venus, pointing to possible analogues with Earth's Archean greenstone belts. George Tilton (University of California, Santa Barbara) treated crust-mantle geochemical differentiation in the Archean based on the evidence of Pb isotopes. Sm-Nd isotopic systematics of the Ancient Gneiss Complex of South Africa, and of rocks in the Rainy Lake area, Ontario, were discussed in two papers respectively by R.W. Carlson (Carnegie Institution), D.R. Hunter (University of Natal) and F. Barker (USGS), and S.B. Shirey and Gil Hanson (SUNY, Stony Brook). Listeners were then vicariously brought back to India, this time by J.D. Macdougall (Scripps, La Jolla, California) and three co-authors who discussed a possibly depleted mantle source under Archean crust in Rajasthan. The day's last formal paper, by Ken Collerson (ANU, formerly of Memorial University), reported 3.9 Ga zircons from the Uivak gneisses in northern Labrador, the oldest ages yet reported from the North American-Greenland landmass. At the prodding of colleagues, Collerson closed the afternoon with an informal report on work just carried out on the ANU ion microprobe by a number of graduate students under the supervision of W. Compston. This work, now in press, determined the existence of zircons at Mt. Narryer, Western Australia, between 4.1 and 4.2 Ga old! The "beginning" gets pushed back farther and farther. Collerson's presentations were illustrated with macro- and microslides; on the one hand, the room-filling ANU ion microprobe, and on the other, the 20μ-diameter pits sputtered into the surfaces of the analyzed zircons.

The field trip began the next day, Thursday, with an 800-km, all-day ride by chartered bus to Sault Sainte Marie. "Day 1", the first working day of the field trip, was Friday, when in the Wawa area the lowest-grade part of the Michipicoten greenstone belt was examined in roadcuts as well as in active and abandoned iron mines. Metaconglomerates, a variety of felsic metavolcanic rocks with well-preserved primary textures, mafic metavolcanic rocks (locally pillowed), oxide and carbonate iron formations, and metasomatic(?) chloritoid rocks evoked lively discussions and the expenditure of vast quantities of film. At some outcrops, the clicking of shutters masked the blows of hammers.

Day 2 brought the field trip eastward into the amphibolite-grade Wawa domal gneiss terrane in the vicinity of Chapleau, a railroad town deep in the bush. Here participants viewed tonalite gneisses with enclaves of amphibolite interpreted to be partly digested dismembered fragments of Michipicoten greenstone; various granitic rocks disposed in a series of domes; and, at the day's end, "granulite" gneiss in the Robson Lake dome which shares the structural attributes of the Wawa domal gneiss terrane and the lithological characteristics of the Kapuskasing structure. Hotly discussed on Day 2 was the significance of the fine-scale and persistent layering in the felsic and intermediate gneisses.

On Day 3 participants were guided easterly through the Kapuskasing structure, past the Ivanhoe Lake cataclastic zone, and into the Abitibi greenstone belt beyond, ending up at Timmins. Gneisses in the Kapuskasing structure are relatively more mafic than those in the Wawa domal gneiss terrane, and many are characterized by interlayers of gneiss with garnet + clinopyroxene + plagioclase and gneiss with hornblende + garnet. Whether these mineralogical contrasts are the result of retrograde metamorphism, P_{H_2O} gradients during prograde metamorphism, or compositional differences in protoliths made a subject of lively debate among the petrologists. Another provocative subject was: what is the role of orthopyroxene in defining granulite?

Two stops in the Shawmere anorthosite complex were particularly impressive. The complex makes up an irregular, lens-shaped, regionally concordant pluton 50 km by 15 km, with a satellite body to the south. Coarse-grained anorthosite, gabbroic anorthosite, and gabbro, in part deformed cataclastically, elsewhere with corona textures, are the chief rocks. Grey intermediate to calcic plagioclase, garnet, black hornblende and orthopyroxene are conspicuous in hand specimens. The Ivanhoe Lake cataclastic zone, not well exposed, was studied in a single outcrop where mafic gneiss is sliced by veins of black recrystallized aphanitic mylonite. The Abitibi greenstone belt immediately east of the cataclastic zone is made up of fine-grained, layered, east-striking, little-disturbed basaltic metavolcanic rocks. The contrast is remarkable between these weakly metamorphosed rocks and the coarse-grained, high-grade, northeast-striking banded gneisses in the Kapuskasing structure across the cataclastic zone only a few hundred metres to the west. Consistently east-dipping Archean basaltic dikes in the Kapuskasing structure were cited as additional evidence of upward-ramping on an inferred west-dipping basal fault.

Day 4 was spent in the Abitibi greenstone belt in the vicinity of Timmins where numerous metavolcanic and metasedimentary rocks of greenschist and subgreenschist grade were examined. At the first stop an enthusiastic discussion took place concerning top-and-bottom criteria on an outcrop cleaned with bleach (here I learned a new verb—"to javex") that exposes an angular unconformity between greywacke and overlying conglomerate. Altered and pillowed(?) komatiites were seen on Dead Man's Point, a promontory covered by a cemetery on the east shore of Porcupine Lake. Complex successions of Mg-rich and Fe-rich metatholeiites were examined at a rambling series of outcrops at the "Mental Hospital Stop". Day 4 ended earlier than previous days in the field to permit a late-afternoon meeting at the motel to discuss plans for future Early Crustal Genesis meetings, and to summarize in writing work under way or planned on the Kapuskasing structure. Larry Jensen (OGS) closed the day's formalities with a talk that illustrated his views on the origin of Archean greenstone belts.

About half the participants left the trip at Timmins early on Day 5. The enthusiasts who remained carried on to see komatiitic and other metavolcanic and metasedimentary rocks of the Abitibi greenstone belt at Kirkland Lake. "No-hammer outcrops" included komatiite with spinifex texture, and metaconglomerate with komatiite clasts. Following a final roadside lunch, the bus headed east and was back in Ottawa early Tuesday evening.

In my opinion, the field trip focused successfully on the problem under scrutiny. Through a series of well-chosen exposures, mostly of excellent quality, the pieces of the Kapuskasing puzzle were viewed in their logical order. Surprising, however, was the limited areal extent of undisputed granulites. In part these rocks are spatially related to the Shawmere anorthosite complex, a structurally and petrologically snarled unit with evidence of having been transported upward relative to enclosing rocks. Certainly the presence of granulite-facies rocks in the Kapuskasing structure requires explanation, but their quantitative importance pales before the thousands of square kilometres of granulite exposed elsewhere in the Superior province, the Churchill province and the Grenville province. Then, although the age of the thrusting thought to be responsible for the Kapuskasing structure is known imprecisely, it is no younger than early Late Proterozoic, and it may be Archean (Percival and Card, 1983). The operation of compressional forces on such a vast scale is not in accord with the commonly-held view of the dominance of vertical tectonics in early Earth history. Lithoprobe studies in the Kapuskasing structure, particularly seismic experiments, should provide answers to many questions yet unanswered about this fundamental crustal feature of the shield.

The field trip was led by Ken Card,

(GSC); John Percival (GSC); Ron Sage (OGS); Lorne Luhta (MNR); and Larry Jensen (OGS). The expertise of these men was impressive and made the trip a scientific success. Arrangements for lodging and most meals were carried out by Le-Becca Turner (LPI) and Scott Young (GSC), who followed the bus in a station wagon and daily would dart ahead at mid-day to set up at pre-arranged roadside sites generous picnic lunches with the coldest beer this reporter has ever downed in the field. The high quality of this support was made clear when the chartered bus broke down at the lunch stop on Day 2, pretty much in the middle of nowhere. In what seemed like no time at all, a school bus had been brought from Chapleau and the trip carried on without loss of pace! The joining of such exceptional support with the high quality of leaders, remarkable geology, uninterrupted fine weather, absence of black flies and abundant ripe blueberries at nearly every stop made the 1983 Kapuskasing field trip memorable.

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