GEOLOGY OF WRANGEL ISLAND BETWEEN CHUKCHI AND EAST SIBERIAN SEAS, NORTHEASTERN RUSSIA - EXCERPTS FROM GEOLOGICAL SURVEY OF CANADA 1993 BULLETIN 461

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ABSTRACT

The oldest unit on Wrangel Island is the Upper Proterozoic Wrangel Complex, a 2,000+-m succession of volcanic and clastic sedimentary rocks with small mafic and granitic intrusives and U-Pb crystallization ages of 0.63 to 0.70 Ga. The oldest Paleozoic unit is a 700-m succession of Upper Silurian and Lower Devonian clastic and carbonate strata. These strata are overlain in ascending order by 1,200 m of Devonian clastic rocks; 350 m of Lower Carboniferous clastic rocks, with conglomerate, carbonate, and gypsum; 1,400 m of Carboniferous carboniferous carbonate with slate and bioherms; 750-m-thick Permian slate and limestone, locally with olistostrome and breccia; 800 to 1,500 m of Triassic flysch; and, finally, tens of meters of undeformed Tertiary and Quaternary clastics. All rock units of Proterozoic to Triassic age were pentratively deformed into north-verging structures, and metamorphosed to greenschist facies, during the Mesozoic Chukotkan Orogeny (Middle Jurassic to Early Cretaceous).

Some aspects of Wrangel Island's tectonic history in the circum-Canada Basin are peculiar. The most important are late Proterozoic magmatism, inferred latest Proterozoic-Early Paleozoic orogenesis, Triassic flysch, Chukotkan deformation, and late-Early Cretaceous overlap of all northeastern Russian terranes by the Upper Cretaceous Okhotsk-Chukotsk volcanic belt.

STRATIGRAPHY

The Upper Proterozoic Wrangel Complex outcrops in the central mountains and consists of more than 2,000 m of felsic to intermediate volcanic rocks, volcaniclastic rocks, and slate/phyllite, with minor grey and black slate, quartzite, conglomerate, and very minor mafic volcanic rocks. (Fig.1 shows the simplified geology of Wrangel Island and includes an index map.) Wrangel Complex strata are intruded by quartz-feldspar porphyry, gabbro, diabase, felsite dykes and sills, and by small granitic bodies. The sedimentary rocks probably are marine; the tectonic setting of the volcanic rocks remains uncertain. Within the Wrangel Complex, U-Pb zircon dating has provided crystallization ages of 633 +21/-12 Ma and 699 ±2 Ma, respectively, and a ca. 0.7 Ga for a volcanic rock, a granitic rock, and a leuco-granite, respectively (Cecile et al., 1991).

The oldest Paleozoic unit on Wrangel Island is a 700-m succession of Upper Silurian and Lower Devonian shallow marine, sandstone, siltstone, slate, and carbonate, found only in the northwestern and western parts of the island.

These strata are overlain by a 1,200-m-thick Devonian succession of marginal marine followed by deep marine clastic rocks, with conglomerate. In the south of the island, this unit directly overlies the Wrangel Complex.

In the central mountains, Devonian strata are overlain by a 350-m-thick succession of Lower Carboniferous, proximally sourced, extension-related, marine and nonmarine clastic rocks, including sedimentary-clast conglomerate, slate, argillite, and minor carbonate and gypsum.

This unit is overlain by up to 1,400 m of additional Carboniferous that includes a northwestern shallow-water, limestone-dominated facies belt and a southeastern transitional limestone and slate belt.

Above these strata is a 750-m-thick succession of Permian slate and limestone with minor sandstone, coarse clastic rocks, and siliceous strata, and in the north, an olistostrome-breccia succession. In and to the north, Permian strata overstep Silurian to Carboniferous units. These Permian lithofacies represent environments ranging from land, initially, to, with time, platform carbonates on the northwest to basin shale and chert on the southeast. Also on the south-center of the island, Permian and Carboniferous strata are missing beneath Triassic strata, either through erosion or structural omission.

Permian strata are overlain by 800 to 1,500 m of Triassic flysch derived from uplifts to the southwest, south, and southeast associated with volcanism.

DEFORMATION

All rock units of Proterozoic to Triassic age on

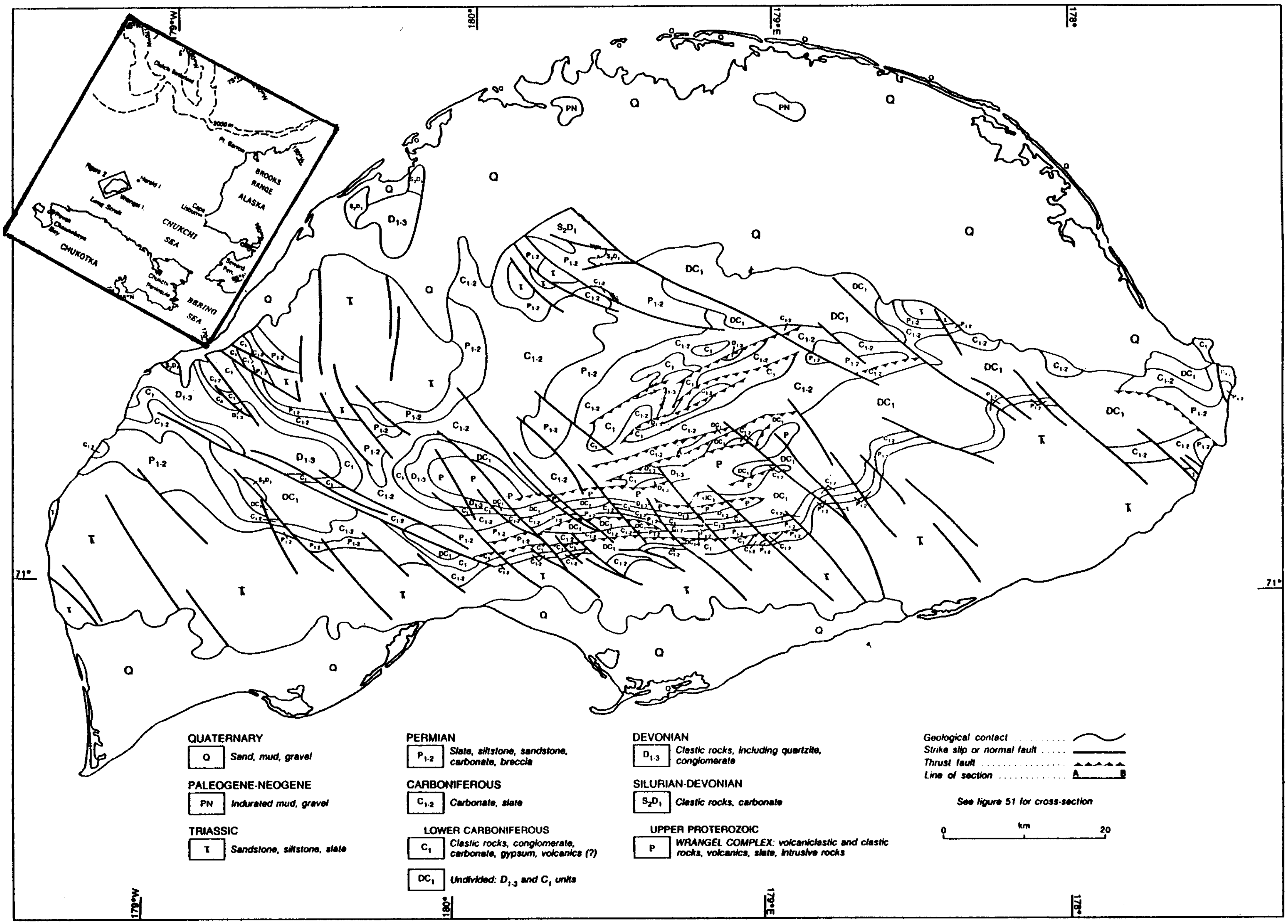

Fig.1. Simplified geology of Wrangel Island from a compilation of Kameneva and Chernyak (1973, 1974); new data from recent field work of M.K. Kos'ko, N.V. Khandozko, V.G. Ganelin, and B.G. Lopatin and unpublished maps of K.S. Ageev (Ageev, 1979). Fig.9 of Kos'ko et al., 1993.

Wrangel Island were involved in the Chukotkan Orogeny (Middle Jurassic to Early Cretaceous). They were penetratively deformed and metamorphosed to lower greenschist facies. Typical structures include a pervasive south-dipping cleavage, north-verging folds, thrusts, normal faults, and strike-slip faults. Nearly all Chukotkan structure on Wrangel Island can be accounted for in a four-stage, thin-skinned tectonic model. There are multiple detachments throughout the deformed succession. The major detachments are in Wrangel Complex slate, Devonian slate, and Permian slate. Shortening appears to be at a maximum at the island center and decreases both east and west.

POST-OROGENIC STRATA

Large depositional basins formed on the continental shelf around Wrangel Island following Chukotkan orogenesis. Only a few tens of meters of post-orogenic Paleogene and Neogene clay and gravel deposits are present on Wrangel Island. The youngest stratigraphic unit on the island is a unit consisting of a few meters of indurated Pliocene mud and gravel, overlain by unconsolidated Quaternary clastic rocks.

TECTONIC-DEPOSITIONAL HISTORY

Inferences from depositional environments, rock composition, isotopes, and structural analysis give the following history. Wrangel Island is underlain by Precambrian basement. The oldest documented tectonic event is Proterozoic volcanism and plutonism, followed by inferred early Paleozoic orogenesis that culminated with substantial uplift and cooling. By Late Silurian, stable miogeoclinal facies were established. These facies were replaced in the Devonian by a marginal marine belt, which in turn was followed by a deep marine facies. Extensional tectonism, with inferred local uplifts and rift basins, was associated with deposition of Lower Carboniferous strata. Stable shelf facies conditions were reestablished during the remainder of the Carboniferous with shelf facies in the northwest and basin facies to the southeast. By Permian time, the northwestern part of the island was uplifted and eroded during a period of renewed rifting, while the southeast remained submerged. By Late Permian, the entire island was inundated. Platform carbonate facies replaced land areas in the northwest, while the southeast continued to submerge. By Triassic time, the Wrangel Island area was completely submerged and receiving flysch from southern highlands associated with volcanism. Following the Triassic, all rocks underwent Chukotkan deformation and metamorphism and subsequently were uplifted and deeply eroded. In late Early Cretaceous time, large extensional basins formed in the continental shelf, near Wrangel Island, and received thick accumulations of Cretaceous to Tertiary strata, including basalt flows and sills.

TABLE OF FORMATIONS

See Table 1.

Table 1. Table of formations (unit/lithology).

QUATERNARY

Unnamed: Coarse clastic alluvium, proluvium, eluvium, and colluvium.

LATE TERTIARY

Unnamed: Indurated Pliocene mud and gravel (a few meters).

TERTIARY

Paleogene-Neogene

PN Unit: Clay and gravel (a few tens of meters thick).

TRIASSIC

Tr Unit: Black to dark grey argillaceous quartz turbiditic sandstone with minor feldspar, lithic fragments, black slate, and minor siltstone (total thickness estimated to be 800-1,500 m).

PERMIAN

P_{1-2} Unit: Slate and limestone with minor sandstone, coarse clastic, and siliceous strata. In the north, the basal part contains a thick olistostrome-breccia succession (up to 750 m thick).

CARBONIFEROUS

C_{1-2} Unit: Two facies types: (1) microcrystalline and crinoidal biocalcarenite; fine-grained, thin-bedded limestone; minor slate; and argillite and (2) limestone interstratified with slate and argillite (up to 1,400 m thick).

LOWER CARBONIFEROUS

C_1 Unit: Clastic rocks, including intrabasinal conglomerate, slate, and argillite, with gypsum and carbonate (up to 350 m thick).

DEVONIAN

D_{1-3} Unit: Immature clastic rocks, including sandstone, argillite, slate, and conglomerate (as much as 1,200 m thick).

SILURIAN-DEVONIAN

S_2D_1 Unit: Fossiliferous quartzose sandstone, siltstone, slate, and carbonate (total thickness, 700 m).

LATE PROTEROZOIC

Wrangel Complex: Felsic to intermediate volcanic and volcaniclastics rocks, sericitic, and chloritic slate/schist with minor grey and black slate, and very minor mafic metavolcanics, quartzite, and metaconglomerate; intruded by quartz-feldspar porphyry, metagabbro, metadiabase, and aplitic felsic dykes and sills and small elongate granitic and aplitic intrusive bodies (total thickness > 2,000 m).

SYNTAXIS

To the east of Wrangel Island, the front of intense Chukotkan-Brookian deformation is abruptly offset right-laterally about 600 km northward relative to its position in Alaska. As a result, the front passes north of Wrangel Island. This offset either is a large salient in the orogen and/or is due to strike-slip movement. This feature is known as the Chukchi syntaxis (Tailleur and Brosgé, 1970).

CIRCUM-ARCTIC COMPARISON

Some aspects of Wrangel Island's tectonic history, in the circum-Canada Basin, are peculiar to the Arctic Alaska-Chukotka Ancestral Plate. The most important are late Proterozoic magmatic activity and inferred latest Proterozoic-Early Paleozoic orogenesis; Triassic flysch, which on the mainland are associated with spilitic basalt and tuff; Jurassic-Early Cretaceous Chukotkan deformation; and late-Early Cretaceous overlap of all northeastern Russian terrains (Arctic and Pacific) by the Okhotsk-Chukotsk volcanic belt. In many tectonic models, the latter two would post-date or be associated with formation of the Canada Basin.

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