Lithos 261 (2016) 250–261

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Cretaceous and Paleogene granitoid suites of the Sikhote-Alin area (Far East Russia): Geochemistry and tectonic implications

Andrei V. Grebennikov [a,b,*], Alexander I. Khanchuk [a], Valeriy G. Gonevchuk [a], Sergey V. Kovalenko [c]

[a] Far East Geological Institute, Far Eastern Branch of the Russian Academy of Sciences, 159, Prospekt 100-letiya Vladivostok, Vladivostok 690022, Russian Federation
[b] Far Eastern Federal University, 8, Sukhanova St., Vladivostok, 690950, Russian Federation
[c] Primorgeology, Okeansky Prospekt 29/31, Vladivostok 690091, Russian Federation

A R T I C L E I N F O

Article history:
Received 5 July 2015
Accepted 21 December 2015
Available online 5 January 2016

Keywords:
A- S-, and I-type granites
Petrochemical classification
Tectonic setting, Sikhote-Alin, Russian Far East

A B S T R A C T

The Mesozoic and Cenozoic geological history of NE Asia comprises alternating episodes of subduction or transform strike-slip movement of the oceanic plate along the continental margin of Eurasia. This sequence resulted in the regular generation of granitoid suites that are characterized by different ages, compositions, and tectonic settings. The Hauterivian–Aptian orogenic stage of the Sikhote-Alin, associated with the strike-slip displacement of the early Paleozoic continental blocks, the successive deformation of the Jurassic and Early Cretaceous terranes, and the injection of the earliest S-type granitoids. During late Albian, the area underwent syn-strike-slip compression caused by collision with the Aptian island arc and resulted in the injection of voluminous magmas of calc-alkaline magnesian (S- and I-type) and alkali-calcic ferroan (A-type) granitoids into syn-faulting compressional and extensional basins, respectively. Northwestward to westward movement of the Izanagi Plate resulted in the initiation of frontal subduction of the Paleo-Pacific Plate during the Cenomanian–Maastrichtian. In turn, this resulted in the generation of plateau-forming ignimbrites and their intrusive analogs formed from metaluminous I-type felsic magmas. Paleocene–Eocene magmatism in the Sikhote-Alin area commenced after the termination of subduction in a rifting regime related to strike-slip movement of the oceanic plate relative to the continent. The break-off of the subducted plate and the injection of oceanic asthenospheric material into the subcontinental lithosphere resulted in the eruption of lamproites and fayalite rhyolites, and coeval intrusions of gabbro and alkali feldspar granites (A-type). The A-type granitic-rocks and coeval gabbro–monzonites are considered to be reliable indicators of the transform continental margin geodynamic settings.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The continental area bordering the NW Pacific Ocean has a heterogeneous structure that is a result of the large-scale horizontal displacement of lithospheric plates at continent–ocean boundaries (e.g., Khanchuk (2006), and references therein). The Mesozoic and Cenozoic history of the Pacific margin reflects alternating subduction and transform strike-slip movement of the oceanic plate relative to the continental margin (Khanchuk and Ivanov, 1999; Khanchuk and Kemkin, 2003). Thus, the Sikhote-Alin–North Sakhalin accretionary orogenic belt (herein referred to as the Sikhote-Alin) is a favorable natural laboratory for research on the evolving granitoid magmatism resulting from regional tectonic changes.

Recent data on the tectonics, geodynamics, seismicity, magmatism, and minerals of the Sikhote-Alin (Faure and Natal'in, 1992; Golozubov, 2006; Jahn et al., 2015; Kemkin, 2012; Khanchuk, 2006; Natal'in, 1993; Nokleberg et al., 2000; Parfenov et al., 2010; Şengör and Natal'in, 1996; Utkin, 2013) have helped to identify the main features of the Mesozoic and Cenozoic tectonic history of the Russian Far East continental margin. The tectonic evolution of this area was dominated by strike-slip movement between the continental and oceanic lithospheric plates, involving large plate margin displacements of hundreds or thousands of kilometers, and the initiation of the proto-Central Sikhote-Alin Fault, which is proposed to have controlled the formation of pull-apart basins and the development of numerous magmatic complexes, including A-type granites. The compositions of these granites reflect the complex interplay between intracrustal melts, mantle-derived magmas, and sediments. Coeval intrusions that host gabbros to monzonites and trachybasalts to trachyandesites give evidence of A-type rocks related to mantle-derived magmas. Extension zones developed in the course of transformation of the convergent boundary subduction into a strike-slip-dominated tectonic regime, and this change, combined with the discrete permeability of continental lithosphere, allowed mantle-derived melts to ascend (Khanchuk et al., 1997).

A-type magmatic rocks in a strict sense have not been previously identified in the Sikhote-Alin area (we, however, do not ignore sporadic

* Corresponding author at: Far East Geological Institute, Far Eastern Branch of the Russian Academy of Sciences, 159, Prospekt 100-letiya Vladivostok, Vladivostok 690022, Russian Federation. Tel.: +7 9147050037.
E-mail address: greandr@hotmail.com (A.V. Grebennikov).

http://dx.doi.org/10.1016/j.lithos.2015.12.020
0024-4937/© 2016 Elsevier B.V. All rights reserved.

identifications of this type described in earlier publications, by Jahn et al. (2015), for example), mainly because existing geochemical discrimination diagrams (e.g., Eby (1992); Pearce et al. (1984) and Whalen et al. (1987)) do not differentiate between peraluminous silicic magmas derived from contaminated mantle A-type melts and crustal I- and S-type melts.

This paper summarizes our current understanding of the geodynamic development of the Sikhote-Alin area since the Early Cretaceous, based on existing data related to the regional stratigraphy, metamorphism and tectonics. After considering the occurrence and compositional characteristics of granitoid magmatism (and particularly A-type granites) in the context of their formation during certain geodynamic stages, we propose a new paleogeodynamic model for the Sikhote-Alin area.

2. Geological background

2.1. Geodynamic evolution of the Sikhote-Alin, since the Early Cretaceous

The Sikhote-Alin area represents a collage of terranes of different origins and ages, accreted during the Mesozoic to Cenozoic (e.g., Khanchuk (2006); Khanchuk and Ivanov (1999); Khanchuk et al. (1997); Natal'in (1993); Nokleberg et al. (2000), (2003) and Parfenov et al. (2010)). In the Jurassic, increased subduction of oceanic lithosphere resulted in the accretion of remote continental blocks and island arcs to the margin of the Siberian Craton (e.g., Kemkin (2008) and Natal'in (1993)). During this process, large accreted blocks fragmented into terranes and formed a late Albian–early Cenomanian orogenic belt (Khanchuk, 2001). The accretion of terranes during the Jurassic–Early Cretaceous caused changes in the geodynamic setting along the newly formed continental margin. From the Early Cretaceous to the Eocene, the geodynamic setting changed from Pacific Plate-type transform strike-slip movement (in the late Albian) to an active Andean-type margin (Cenomanian–Maastrichtian), before changing back to transform-type tectonism (Paleocene–Eocene; Khanchuk and Ivanov, 1999). At each of these stages, the craton margins and terranes were stitched together by granitoid batholiths and volcanic–plutonic belts. During the late Cenozoic, rifting and extension formed the depressions of the seas of Japan and Okhotsk, accretion at the Asian continental margin ceased, and the setting changed to a destructive regime (Khanchuk, 2006, and references therein).

In this paper, we use the term Sikhote-Alin to refer to an Early Cretaceous orogenic belt on the Russian Far East continental margin that is unconformably overlain by undeformed Upper Cretaceous and Cenozoic volcanic and sedimentary units. The belt is up to 600 km wide and extends northeastward for ~1500 km from the southern boundary of Primorye to the Amur River mouth and northern margin of Sakhalin Island. The belt is bounded to the west by the early Paleozoic Bureya–Khanka orogenic belt and to the north by the Early Cretaceous Mongol–Okhotsky belt. The Sikhote-Alin contains numerous terranes, including fragments of Jurassic and Early Cretaceous accretionary prisms, and Early Cretaceous terranes formed in an island arc system and in a syn-faulting turbidite basin (Fig. 1). The tectono-stratigraphic sequence in this area suggests that the terrigenous matrix of the accretionary prism formed on top of oceanic crust after the Callovian, in a tectonic setting analogous to those found in present-day deep-sea trenches (Khanchuk, 2006).

During the Mesozoic and Cenozoic, the Sikhote-Alin area was the site of alternating stages of voluminous orogenic and post-orogenic magmatism in the form of numerous intrusive complexes that have common petrographic, geochemical, and geochronological features.

2.2. Hauterivian–Aptian igneous episode (130–120 Ma)

The injection of the earliest (Khungari) granitoids within the Sikhote-Alin was associated with the displacement of the early Paleozoic continental lithosphere, the successive deformation of the Jurassic and Early Cretaceous terranes, and the generation of a metamorphosed granite layer (Khanchuk et al., 2013).

2.2.1. Khungari granitoids

The Khungari granitoids crop out in several batholith-like (>100 km^2) Hauterivian–Aptian massifs that are generally located within the area around the Central Sikhote-Alin Fault (48°00′–50°30′N), and in the Bikinsky zone (46°30′–47°30′N) some 100 km west of the central suture. Small intrusive bodies occur in the early Paleozoic Khanka orogenic belt (44°50′–45°10′N; e.g., Izokh et al. (1967); Simanenko et al. (1997); Fig. 2a).

The granitoids intrude the Jurassic sediments and Late Jurassic E–W-striking pyroxenite, gabbroid, and gabbro–diorite dikes, and can be divided into two types: the dominant first type consists of biotite and two-mica cordierite-bearing diorites, quartz-diorites, and melagranites; the second type consists of fine-grained biotite granite and leucogranite. The granitoids have a similar mineral composition. The main felsic minerals are mainly quartz with lesser albite and microcline (Kruk et al., 2014). The margins of these intrusions are enriched in red–brown biotite (up to 15%–20% modal abundance), whereas the cores are enriched in aluminiferous minerals such as muscovite (10%) and cordierite (up to 2%). No amphibole is present, even in the least silicic varieties of these granitoids. The major minerals are accompanied by accessory ilmenite, zircon, monazite, tourmaline, apatite, garnet, and very rare magnetite (Izokh et al., 1967; Martinyuk et al., 1990).

The geochemistry of the Khungari granitoids (Gvozdev, 2010; Izokh et al., 1967; Kruk et al., 2014; Simanenko et al., 1997) indicates that they are peraluminous and are S-type granites according to the definition of Chappell and White (1974). These granitoids have moderate alkalinity, are predominantly potassic, and contain moderate concentrations of iron. In the classification diagrams of Frost et al. (2001; Fig. 3a–b), they are considered calc-alkalic, alkali-calcic, ferroan, and magnesian. According to the graph of Liégeois and Black (1987; Fig. 3d), they are calc-alkaline rocks. The majority of these granitoids also plot in the volcanic arc granite (VAG) field on the tectonic discrimination diagram of Pearce et al. (1984) and as orogenic granitoids on classification diagrams based on Zr, Nb, Ce, and Y (Whalen et al., 1987; Fig. 3e) and based on the molecular quantities of rock-forming oxides (Grebennikov, 2014; Fig. 3f).

Previous research indicates that the Khungari granitoids intruded Berriasian–Hauterivian sediments that show evidence of contact metamorphism, and are overlain by Barremian–Aptian units, indicating that the granitic-rocks formed during the Valanginian–Hauterivian (Izokh et al., 1967; Martinyuk et al., 1990; Nazarenko and Bazhanov, 1987). Recent Rb–Sr isotopic dating yields ages of 123.7 ± 0.8 Ma ($^{87}Sr/^{86}Sr_i = 0.70909$) to 125.6 ± 0.9 Ma ($^{87}Sr/^{86}Sr_i = 0.70949$; Khetchikov et al., 1997, 1998), and U–Pb − 131.4 ± 2.0 Ma (Jahn et al., 2015) that are consistent with the geological relationships described above. These ages are comparable to U–Pb zircon ages from the Hamahe batholith (124 Ma) and granites in the Raohe Complex (128 Ma) of northeastern China (Cheng et al., 2006; Zhou et al., 2014). The Khungari granitoids formed from magmas generated from a source with a major component of metasediments from the Samarka terrane (εNd = −3.7 to −4.1; Kruk et al., 2014) and that also contained fragments of late Paleozoic and early Mesozoic oceanic crustal material (e.g., basalt, chert, and limestone).

The largest occurrence of tungsten mineralization associated with the Khungari granitoids is the scheelite–quartz ore of the Lermontovskoe deposit (~120 Ma from K–Ar and Rb–Sr dating; Gvozdev, 2010).

2.3. Late Albian igneous episode (110–98 Ma)

During the late stages of orogeny, the Sikhote-Alin area underwent syn-strike-slip compression caused by collision with the Kema island

Download English Version:

https://daneshyari.com/en/article/4715558

Download Persian Version:

https://daneshyari.com/article/4715558

Daneshyari.com