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Review

Gold deposits and gold metallogeny of Far East Russia

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ABSTRACT

The Russian Far East or Far East Russia (FER) is host to a huge gold endowment and has produced more than 6500 t of gold, since the 1860s. Much of this gold has come from several mining districts: Aldan, Upper Amur, Lower Amur, Okhotsk, Allakh-Yun, Yana-Kolyma, Priokhotie, Omolon, and Chukotka. These districts include several gold deposits, mostly of orogenic and epithermal nature, as well as large and very large alluvial placer deposits. The main gold districts are of Late Mesozoic age, but there are also three districts (Aldan, Omolon, and southern Primorie) with pre-Mesozoic gold ores and three districts (Kamchatka, Sakhalin–South Kurile, and Lower Amur) with gold ores of Cenozoic age. This review paper attempts to marshal on the regional scale all available data aiming to provide a framework for generating and testing new ideas on the gold deposits of FER. The focus is on: (1) gold metallogeny, (2) details of key gold deposits, and (3) relationship between gold ore forming processes, metamorphic processes and granitoid intrusions in different geodynamic settings. The largest gold metallogenic belts in FER were formed in the late Mesozoic, namely: in the Late Jurassic (Yana-Kolyma), Early Cretaceous (eastern flank of Mongol–Okhotsk, Aldan, Oloy–Chukotka, Okhotsk–Koryak) and Late Cretaceous (Sikhote-Alin).

The Mesozoic era was also the time when most of the gold-hosting orogens were formed. Paleozoic, Mesozoic and Cenozoic orogens resulted from the interaction between the Pacific oceanic plates with the Siberian craton and the North China craton. These orogens are products of diverse geodynamic settings and can be divided into four types: (1) collisional (e.g., Yana-Kolyma), (2) accretionary or uncompleted collisional (e.g., Okhotsk–Koryak or Kamchatka), (3) combined collisional and transform margin (Mongol–Okhotsk), and (4) active transform margin (Sikhote-Alin). The first two types are typical of North East Russia, whereas the third and fourth types are in the southern part of FER. The Late Cretaceous Okhotsk–Chukotka and East Sikhote-Alin gold provinces are associated with continental margin magmatic arcs and are post-accretionary (post-orogenic).

Comparison of lode gold deposits from different geodynamic settings reveals specific features in metallogeny of the late Mesozoic orogens at the southern and eastern margins of the Siberian craton (Yana-Kolyma collisional orogen, Okhotsk–Koryak accretionary orogen and Mongol–Okhotsk transform margin orogen). These orogens possess different metal associations. The Yana-Kolyma belt contains Au, Sn, W, and Cu–Pb–Zn lode deposits. The Late Jurassic Transbaikalian sector of the Mongol–Okhotsk orogen contains Au, Mo, Pb–Zn, Sn, Ta–Nb, W, Hg–Sb lode deposits, whereas Early Cretaceous Au, Cu–Mo, Hg–Sb lode deposits are present in the Amur sector. Finally, the Okhotsk–Koryak orogen hosts Au, Cu–Mo, Cu–W–Bi, Ag–Co–Bi–As, and Be–Sn–Li–W deposits of Early Cretaceous age.

Epithermal gold deposits occur in two different geodynamic settings: (1) island arcs (Kamchatka, Kurile islands) and magmatic belts at active continental margins (Omolon, Okhotsk–Chukotka and Eastern Sikhote-Alin), and (2) rift-related magmatism, linked with orogenic events and strike-slip kinematics, such as transform-like continental margin settings (Aldan and Upper Amur in the Mongol–Okhotsk orogen). Mineralogic–geochemical and isotope systematics indicate a metamorphic–magmatic origin of hydrothermal–plutonic systems in collisional settings (Yana-Kolyma, Okhotsk–Koryak, and Oloy–Chukotka orogens) and active continental margin (Okhotsk–Chukotka and East Sikhote-Alin) settings, with source contributions from the lower crust and mantle. The Mongol–Okhotsk and Sikhote-Alin orogens are of transform fault-related origin and suggest a source of the ore-forming fluids mostly from the mantle.

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Contents

1. Introduction

Far East Russia (FER) has a huge gold endownment, distributed between several metallogenic provinces, and has produced more than 6500 t of gold since the 1860 s, contributing to Russia's standing as the 4th largest gold producer in 2012, after China, Australia and the USA (USGS Mineral Commodity Summary, 2013). Much of this gold has come from several mining districts: Aldan, Upper Amur, Lower Amur, Okhotsk, Allakh-Yun, Yana-Kolyma, Priokhotie, Omolon, Chukotka, South Primorie, Kamchatka and some additional smaller districts (Fig. 1; Table 1). These districts include numerous lode gold deposits mostly of orogenic and epithermal nature, as well as large and very large alluvial placers.

In terms of ore ranking, we distinguish the following units (from larger to smaller): ore province – ore belt (if linear)/area (if isometric) – ore district – ore deposit. The main gold provinces are of late Mesozoic age, but the three provinces (Aldan, Omolon, and part of the Southwestern Primorie) contain pre-Mesozoic gold ores, and three districts (Kamchatka, Sakhalin–Kurile, and East Sikhote-Alin) have gold ores of Cenozoic age.

These deposits have been investigated by researchers, explorers, and miners, and reports have been published in Russian language papers and books (Amuzinsky, 2005; Amuzinsky et al., 1988; Anert, 1929; Bilibin, 1937; Buryak, 2003; Eirish, 2002, 2003; Firsov, 1985; Gamyanin, 2001; Goncharov, 1983; Khanchuk, 2006; Khomich et al., 1991; Moiseenko and Eirish, 1996; Nekrasov, 1991; Parfenov and Kuzmin, 2001; Rozhkov et al., 1971; Shilo, 1960, 1976, 2002; Sidorov, 1966, 1978; Struzhkov and Konstantinov, 2005; Volkov et al., 2006; and many others). Several geological, genetic, geodynamic, petrologic, exploration models and ideas have been proposed and discussed by prominent Russian geologists (E.E. Anert, Yu.A. Bilibin, N.S. Bortnikov, V.A. Buryak, V.I. Goncharov, V.G. Khomich, V.G. Moiseenko, I.Ya. Nekrasov, V.A. Obruchev, S.V. Obruchev, Yu.S. Rozhkov, N.A. Shilo, A.A. Sidorov, V.A. Stepanov) over a period spanning 150 years. However, English language publications on the gold metallogeny and individual deposits of FER are not many and mostly deal with deposits in North East Russia (Berger, 1993; Gamyanin et al., 2000a,b; Goldfarb et al., 1998; Goryachev, 1995; Goryachev and Edwards, 1999; Goryachev and Yakubchuk, 2008; Nokleberg, 2010; Nokleberg et al., 2005; Yakubchuk, 2009).

This paper attempts to marshal on a regional scale all available data aiming to provide a framework for generating and testing new models on the gold deposits of FER. More specifically, this paper aims to synthesize and reinterpret some of existing geological, geochemical and mineralogical data pertaining to FER gold deposits. The focus is on: (1) gold metallogeny, (2) detailing the large and/or key gold deposits, and (3) relationship between gold ore forming processes, metamorphic processes and granitoid intrusions in different geodynamic settings.

2. A brief history of gold mining

Gold production in FER commenced in 1868 in several major gold fields in the Amur mining districts, but the first discovery of alluvial gold took place in the Okhotsk mining district in 1829 (Anert, 1929). Initial production was from very rich alluvial workings in the Upper and