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The Jiaodong gold district, northeastern China, in the context of the Late Paleozoic and Late Mesozoic large igneous provinces, orogeny and metallogeny in Eurasia

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ABSTRACT

The Permo-Triassic continental large igneous provinces (LIPs) of Eurasia linked in to orogenic systems in decay. Their bulk appearance varies from the massive flood-basalts and (ultra)mafic intrusives to the groups of coeval, widely spread, diverse intrusions and extrusions of the Scattered Igneous Provinces (SIPs). In the interval from the demise of the orogens to the inception of the LIPs and SIPs, diverse ore deposits were formed which, depending on the predominant expression of the hosting system, have been interpreted as orogen-related and LIP- or SIP-related. In the case of the voluminous (ultra)mafic complexes, a mantle origin is indicated. This leads to the concept of active mantle plumes issuing from the core–mantle boundary in view of the exceptional volumes and the high temperature inferred to melt the source complexes. However, the substantial volumes of fluids that entered the sub-continental mantle on prior subduction of oceanic lithosphere lowered the solidus temperature and modified the composition of the sub-continental mantle. As a consequence, the conditional high temperature is superfluous. In this context, the setting of the Jiaodong Province and the evolution of the hosting North China Craton suggest that:

1 the introduction of fluids during prolonged subduction of oceanic lithosphere can also modify the rheology of the deep lithosphere; this reinforces the role of plate tectonic processes in the generation and the in-and extrusion of voluminous, mantle-derived melts;
2 the prolific gold deposits could form because of the stalled, subducted Pacific lithosphere slab with its oxidizing potential and its position within the mantle transition zone; as elsewhere, continent-scale, translithospheric strike-slip deformation played an indispensable role in decompression and in the migration of melts, fluids, volatiles and metals;
3 orogenic gold deposits can form independent of orogenesis; should, after all, a relevant orogen be delineated in the coastal belt of eastern Asia, the question arises concerning the dependence of orogenic gold deposits on the nature of an orogen.

1. Introduction

Ever after the seminal paper by Dobretsov (1997), Asia has been the principal scene of inferred mantle plumes as the sources of the continental, Late Paleozoic Siberian, Tarim and Emeishan Large Igneous Provinces (LIPs; Fig. 1). At about the same time, Doblas et al. (1998) drew attention to the Late Carboniferous–Early Permian volcanism in Western Europe and Northwest Africa as a large igneous province in a complex framework of collapse of the Variscan Orogen, its final disruption by wrench faulting, the release of heat that had accumulated below Pangea, and a superplume. In view of the widely spread distribution of the volcanic complexes Doblas et al. (1998) coined the term 'scattered igneous province'. Dobretsov et al. (2010) formally recognized the Early Permian volcanics in Western Europe as the 'Central European Large Igneous Province' and summarized the diverse ore deposits generally associated with large igneous provinces: 'magmatic Cu–Ni–Pt and Fe–Pt; hydrothermal Ni–Co–As (±Ag, U, Au), Au–As, Ag–Sb, Au–Hg, Sb–Hg and stratiform Cu (copper-bearing sandstones and shales enriched in Co, Ni, Ag, Pt)'. However, in Western Europe, the hydrothermal types, of Late Paleozoic age, are generally viewed as exponents of the Variscan Orogen (e.g., Marignac and Cuney, 1999; Spiering et al., 2000; Bouchot et al., 1997, 2005; see also De Boorder, 2012, 2014). A striking example of this ambivalence is represented by the 'orogenic' gold deposits in the French Massif Central (Bouchot et al., 1997, 2005)

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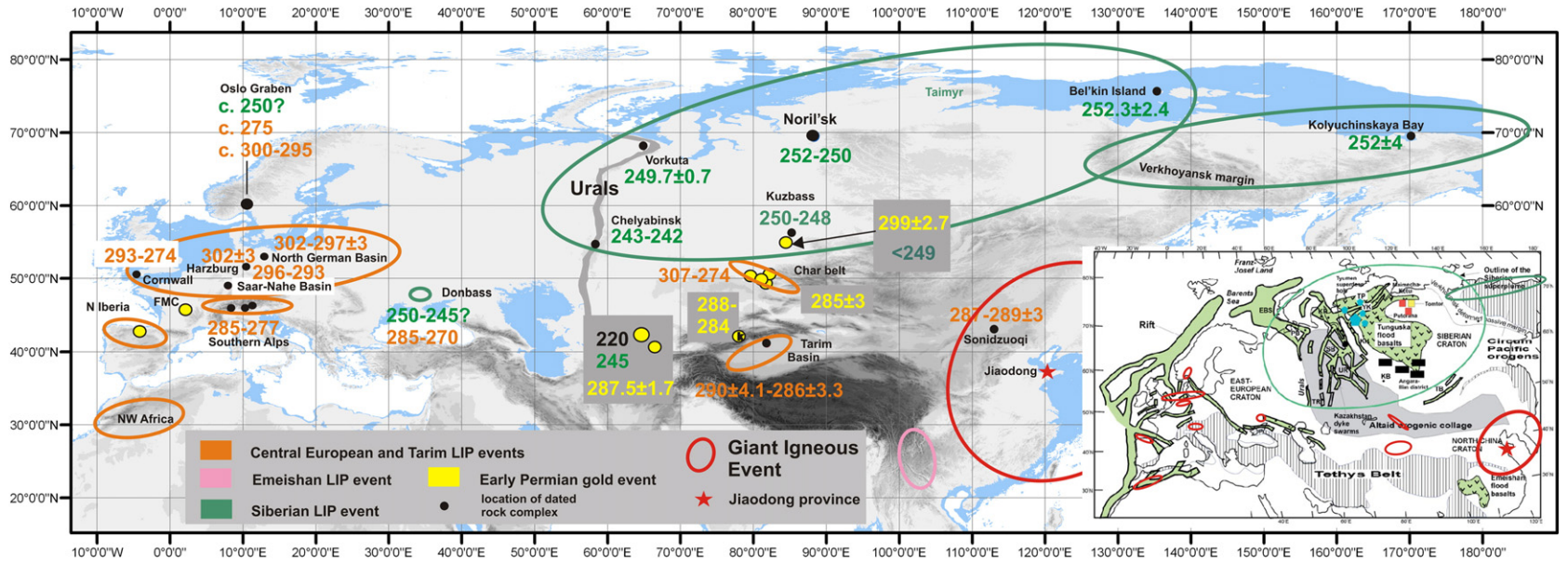

Fig. 1. Schematic overview of the distribution of Early Permian–Triassic large igneous provinces of Eurasia and the Jiaodong gold district. Sources: *Western Europe* — Benek et al. (1996), Breitkreuz and Kennedy (1999), Vinx (1982), Baumann et al. (1991), Von Seckendorff et al. (2004), Schmidberger and Hegner (1999), Vavra et al. (1999), Schaltegger and Brack (2007), Henk et al. (1997), Mulch et al. (2002), Rottura et al. (1998), Hansmann et al. (2001), Tribuzio et al. (1999), Monjoie et al. (2001), Bussy et al. (1998), Montanini and Tribuzio (2001), Cocherie et al. (2005), Fernández-Suárez et al. (2000), Dias et al. (1998). *Southern Tianshan* — Seltmann et al. (2011, 2012), Konopelko et al. (2007, 2009), Wang et al. (2009), Laurent-Charvet et al. (2003), De Jong et al. (2009), Qin et al. (2011), Su et al. (2011), Tian et al. (2010), X. Zhang et al. (2011). *Northern Eurasia* — Timmerman et al. (2009), Reichow et al. (2009), Kuzmichev and Pease (2007), Ledneva et al. (2011), Ivanov et al. (2009), Alexandre et al. (2004). *Early Permian gold event* — Spiering et al. (2000), Bouchot et al. (2005), Morelli et al. (2007), Seltmann et al. (2012), Mao et al. (2004), Naumov et al. (2010).
Modified after De Boorder (2014); inset modified from Nikishin et al. (2002).