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The geology and genesis of the iron skarns of the Turgai belt, northwestern Kazakhstan

T. Hawkins [a,b], M.P. Smith [a,*], R.J. Herrington [b], V. Maslennikov [c], A.J. Boyce [d], T. Jeffries [e], R.A. Creaser [f]

[a] School of Environment and Technology, University of Brighton, Brighton BN4 2GJ, UK
[b] Department of Earth Sciences, The Natural History Museum, London SW7 5BD, UK
[c] Institute of Mineralogy, Miass, Russia
[d] SUERC, East Kilbride, Glasgow G75 0QF, Scotland, UK
[e] Core Research Laboratories, The Natural History Museum, London SW7 5BD, UK
[f] Department of Earth & Atmospheric Sciences, University of Alberta, 126 ESB, Edmonton, Alberta T6G 2R3, Canada

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ABSTRACT

The magnetite deposits of the Turgai belt (Kachar, Sarbai and Sokolov), in the Valerianovskoe zone of the southern Urals, Kazakhstan, contain a combined resource of over 3 Gt of iron oxide ore. The deposits are hosted by carbonate sediments and volcaniclastic rocks of the Carboniferous Valerianovka Supergroup, and are spatially related to the gabbroic to granitoid composition intrusive rocks of the Sarbai–Sokolov intrusive series. The magnetite deposits are developed dominantly as metasomatic replacement of limestone, but also, to a lesser extent, of volcanic rocks. Pre-mineralisation metamorphism and alteration resulted in the formation of wollastonite and the silicification of limestone. Magnetite mineralisation is associated with the development of a high temperature skarn assemblage of diopside, grossular–andradite garnet, actinolite, epidote and apatite. Sub-economic copper-bearing sulphide mineralisation overprints the magnetite mineralisation and is associated with deposition of hydrothermal calcite and the formation of an extensive sodium alteration halo dominated by albite and scapolite. Chlorite formation accompanies this stage and further later stage hydrothermal overprints. The replacement has in places resulted in preservation of primary features of the limestone, including fossils and sedimentary structures in magnetite, skarn calc-silicates and sulphides.

Analysis of Re–Os isotopes in molybdenite indicates formation of the sulphide mineral assemblage at 336.2 ± 1.3 Ma, whilst U–Pb analyses of titanite from the skarn alteration assemblage suggests skarn alteration at 326.6 ± 4.5 Ma with re-equilibration of isotope systematics down to ~270 Ma. Analyses of mineral assemblages, fluid inclusion microthermometry, O and S isotopes suggest initial mineralisation temperatures in excess of 600 °C from hypersaline brines (45–50 wt.% NaCl eq.), with subsequent cooling and dilution of fluids to around 150 °C and 20 wt.% NaCl eq. by the time of calcite deposition in late stage sulphide-bearing veins. $\delta^{18}O$ in magnetite (−1.5 to +3.5‰) and skarn forming silicates (+5 to +9‰), $\delta^{18}O$ and $\delta^{13}C$ in limestone and skarn calcite ($\delta^{18}O$ +5.4 to +26.2‰; $\delta^{13}C$ −12.1 to +0.9‰) and $\delta^{34}S$ in sulphides (−3.3 to +6.6‰) and sulphates (+4.9 to +12.9‰) are all consistent with the interaction of a magmatic-equilibrated fluid with limestone, and a dominantly magmatic source for S. All these data imply skarn formation and mineralisation in a magmatic–hydrothermal system that maintained high salinity to relatively late stages resulting in the formation of the large Na-alteration halo. Despite the reported presence of evaporites in the area there is no evidence for evaporitic sulphur in the mineralising system.

These skarns show similarities to some members of the iron oxide–apatite and iron oxide–copper gold deposit classes and the model presented here may have implications for their genesis. The similarity in age between the Turgai deposits and the deposits of the Magnitogorsk zone in the western Urals suggests that they may be linked to similar magmatism, developed during post-orogenic collapse and extension following the continent–continent collision, which has resulted in the assembly of Laurussian terranes with the Uralide orogen and the Kazakh collage of the Altaids or Central Asian Orogenic Belt. This model is preferred to the model of simultaneous formation of very similar deposits in arc settings at either side of an open tract of oceanic crust forming part of the Uralian ocean.

* Corresponding author.
E-mail address: martin.smith@brighton.ac.uk (M.P. Smith).

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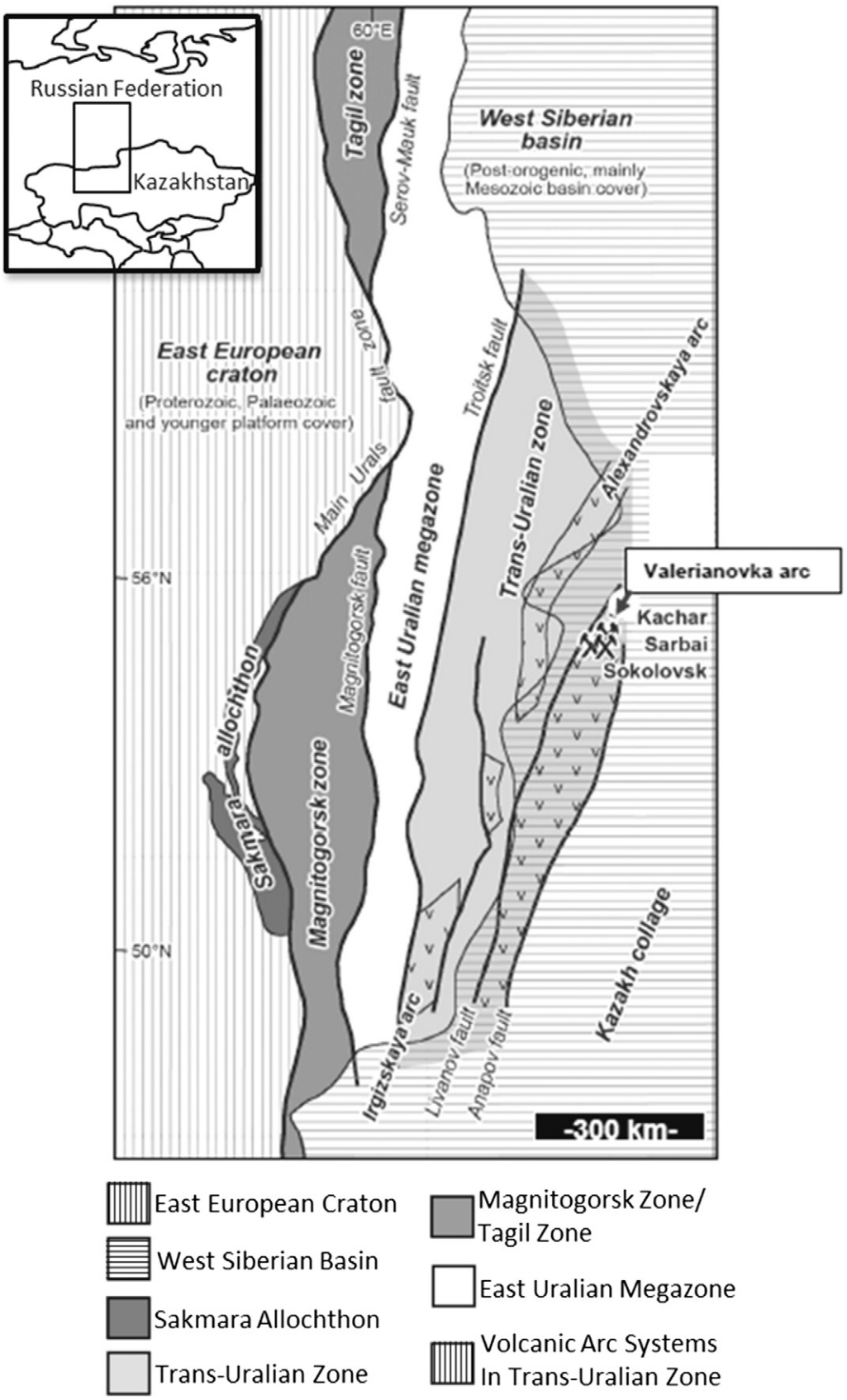

Fig. 1. Simplified map showing the location of the Valerianovka arc, and tectonic sketch map of the southern Urals in Russia and Kazakhstan (after Brown et al. (2002); Herrington et al. (2002); R.J. Herrington et al. (2005b)), showing principle deposit localities. Shading of West Siberian Basin over the East Uralian Zone (notably at the Valerianovka Arc) indicates the continuation of the zone under Mesozoic cover.