Fractal properties of multi-order folding as a tool for exploration of low-grade banded iron ores in the Kirivoy Rog Basin (Ukraine)

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ORIGINAL PAPER

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The low-grade Palaeoproterozoic stratabound banded iron ores of the Krivoy Rog basin (Ukraine) underwent strong tectonometamorphic deformation into superimposed folds of several orders, with amplitudes from centimetres to hundreds of metres. The across-strike sections of bed surfaces defining the low-grade ore bodies resemble self-similar fractal curves; hence, a fractal geometrical model was developed in order to quantify the complexity and sinuosity of bed contours. Two different methods of measurement (polygonal approximation and two-dimensional grid cell counting) were used for 5-8 different scales. Factual similarity dimension D and other model parameters have been estimated by means of linear regression and compared for both measurement methods. From the fractal model a sinuosity coefficient of contours of the folded bed surfaces $K\ s$ and a coefficient of degree of exploration of iron ore bodies $K\ e$ were constructed. It is pointed out that parameters of the model can be used for determination of the optimal exploration length scales.

Key words Fractal geometry - Iron ores - Banded iron formations - Prospecting and exploration - Structural geology

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Introduction

Early Precambrian basins of banded iron formation (BIF) contain approximately 80% of the world iron resources. In particular, the Krivoy Rog basin, located in the central part of the Ukraine, has been intensively studied over 100 years because of mining of both the high-grade and low-grade iron ores. It is a narrow synclinorium extending up to 75 km in the submeridional direction, filled with metamorphic rocks of the Krivoy Rog Supergroup, folded and cut by several major submeridonal thrusts (Fig. 1). The Lower Proterozoic Krivoy Rog Supergroup (series in Russian nomenclature) according to Belevtsev et al. 1983, and Kulik and Korzhnev 1995, is subdivided into five groups (suites):

1. New Krivoy Rog Group (metabasite units overlying quartzite and metasandstone horizons)
2. Skelevat Group (metaconglomerate, metasandstone, phyllite, talc-actinolite schist units)
3. Saxagan (iron ore) Group (alternations of up to seven pairs of BIF and ferruginous shist units)
4. Gdantsev Group (metamorphosed breccia of BIF rocks, metasandstone, black schist and dolomite marble units)
5. Gleevat Group (mainly metaconglomerate and metasandstone beds).

The total thickness of the Krivoy Rog Supergroup reaches 5–6 km, whereas that of the iron-ore Saksagan Group comprises up to 1400 m.

Compared with other BIF basins of the same age (Hamersley in western Australia or Transvaal in South Africa), rocks of the Krivoy Rog Supergroup underwent stronger metamorphism, up to epidote–amphibolite facies (Belevtsev et al. 1983). The BIF rocks and ores of the Saksagan Group display typical multi-order banding (Fig. 2), most prominent on a mesoband (millimetre/centimetre) scale, where it consists of packages (1 cm to 1 m thick) of quartz; Fe-oxide (magnetite, haematite); mixed quartz/Fe-oxide (or quartz/Fe-carbonate) mesobands, separated by the irregularly spaced "schist" (silicate) interbands containing chlorite, biotite, stilpnomelane, albite, carbonate and pyrite in various proportions (Kulik 1991; Kulik and Korzhnev 1995). These interbands often show signs of shearing in the folded parts of the banded BIF rock.

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