



Deformation-induced silica redistribution in banded iron formation, Hamersley Province, Australia



Mathias S. Egglseder*, Alexander R. Cruden, Andrew G. Tomkins, Christopher J.L. Wilson

Monash University, Department of Earth, Atmosphere and Environment, 3800, VIC, Clayton, Australia

ARTICLE INFO

Article history:

Received 10 May 2016

Accepted 24 September 2016

Available online 12 October 2016

Keywords:

Banded iron formation

Hamersley Province

Dissolution-precipitation creep

Pressure solution

Microtectonics

Diagenesis

ABSTRACT

The formation of banded iron formations (BIF) remains controversial despite their potential to provide key information on Precambrian atmospheres and hydrospheres. It is widely agreed that BIF are chemical sedimentary rocks comprising alternating layers of iron oxides and chert formed from poorly known precursor phases. Many models address the chemical transformation of such precursor iron oxide phases into BIF during compaction and diagenesis. However, the formation of chert and the influence of physical forces in this process have received less attention.

Microstructural analysis of BIF from the Hamersley Province (Western Australia) reveals that significant amounts of silica were redistributed by dissolution-precipitation creep during both diagenesis and regional-scale deformation. This physicochemical process led to silica remobilisation and volume loss by stress-induced dissolution of microcrystalline quartz in an aqueous fluid. The dissolved solid phase was transported by diffusion and fluid flow along grain boundaries or within available porosity and then reprecipitated in low-pressure zones, leading to local volume increase. These processes were further enhanced by rheological contrasts between different minerals, resulting in significant variations of chert band thickness.

Microstructural observations combined with quantitative microfabric analysis reveal domains of crystallographic preferred orientations (CPO) in quartz grains within chert layers. The CPO fabrics record strain regimes (e.g., pure and simple shear, extension and shortening) that modified quartz aggregates by dissolution-precipitation creep, providing new insights into the metamorphic and deformation history of BIF. We document microstructures that indicate that non-coaxial deformation was active during diagenesis and subsequent deformation of the Hamersley Province BIF. Further, relatively undeformed chert layers may have been similarly affected by significant amounts of dissolution-precipitation creep, providing a possible explanation for the destruction of primary features.

We show that different generations of chert alternate on a micro-scale, suggesting that the role of deformation has been underestimated in many aspects of BIF research. The discovery of dissolution-precipitation creep in low-grade metamorphic BIF provides a potential link between the physical and chemical processes that occur within these rocks after deposition. In the Hamersley Province, dissolution-precipitation creep was active from the compaction or diagenesis stage and probably operated during all major extensional and compressional deformation events. We also suggest that chert layers without CPO record the least overprint by diagenesis, and as the most pristine form of BIF should be targeted for future paleo-environmental research.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Banded iron formations (BIFs) record Precambrian ocean and atmosphere conditions, the global rise of oxygen, and they host the largest iron-ore deposits on Earth (e.g., Bekker et al., 2010; Morris and Kneeshaw, 2011). Despite decades of research, the question of how BIF have formed, and the variety of conditions required, remains controversial (e.g., Konhauser et al., 2007; Wang et al., 2009). A key challenge is that BIF does not form in modern environments, which is exacerbated

by the fact that Precambrian oceanic and atmospheric conditions have largely been inferred from BIF mineral assemblages that are predominantly diagenetic or metamorphic in origin (e.g., Ayres, 1972; Trendall and Blockley, 1970) and observations of primary precipitates or sedimentary features remain elusive (Konhauser et al., 2005; Krapež et al., 2003; Pecoits et al., 2009). Hence, there is ambiguity on the nature of the primary precipitates or precursors of BIF prior to compaction and diagenesis, their depositional environment, and the processes that lead to the formation of BIF-hosted high-grade iron ore deposits. Nevertheless, studies on Fe, C, Si and O isotope variation between layers have revealed a wide range of mixed primary and diagenetic isotope ratios, which commonly alternate at the microscale (Craddock and Dauphas, 2011; Czaja et al., 2010; Heck et al., 2011; Steinhöfel et al., 2010).

* Corresponding author.

E-mail address: egglseder.mathias@gmail.com (M.S. Egglseder).

Most research on BIF has focused on the petrology of the iron oxide layers, whereas the chert layers have attracted only minor attention. Chert laminae are commonly pale grey, pink, yellow, brown, red or green, varying as a function of the proportion of microscopic particles of iron silicates, iron oxides and iron carbonates (Ayres, 1972; Rasmussen et al., 2015a; Trendall and Blockley, 1970). Modern chert forms from siliceous oozes of biogenic origin via transformation of amorphous silica (opal-A) to opal-CT and finally to microcrystalline quartz (α -quartz) during a series of diagenetic solution-reprecipitation steps (Heaney, 1994; Knauth, 1994). However, as biogenic silica production only started in the Phanerozoic (Maliva et al., 1989) or Neoproterozoic (Perry and Lefticariu, 2014), many different models for the formation of BIF and associated chert bands have evolved. Initially, BIF was interpreted to form as cyclic varves of alternating chert and iron oxide microbands and mesobands that developed by fluctuating redox conditions, or a temporal influx of iron during amorphous silica background precipitation (Cloud, 1973; Ewers and Morris, 1981; Trendall and Blockley, 1970). Alternatively, it has been proposed that the precipitation of precursor phases was controlled by microbes (Konhauser et al., 2007; LaBerge et al., 1987) or by UV-radiation (Cairns-Smith, 1978). Other models suggest that BIF are not chemogenic sediments but form by density-current deposition and hemipelagic settling (Krapež et al., 2003; Pickard et al., 2004; Rasmussen et al., 2015b). Accordingly, chert layers form either on the seafloor as siliceous hardgrounds or immediately below the seafloor by diagenetic replacement of a precursor lithofacies

prior to compaction. Alternatively, it has been suggested that amorphous silica binds to previously precipitated ferric hydroxides (Fischer and Knoll, 2009) or iron silicates (Rasmussen et al., 2015a) and deposits along with organic matter. Depending on the carbon content, compaction and diagenesis may lead to the transformation of ferric hydroxides to hematite, siderite or magnetite (Posth et al., 2013).

The BIFs of the Hamersley Province are part of the Neoproterozoic Hamersley Group (Fig. 1), which comprises five major BIF units intercalated with shales, dolomites and volcanics (e.g., MacLeod, 1966; Trendall and Blockley, 1970). Here, BIF consists of multi-scale bands of alternating chert, iron oxides (magnetite, hematite), iron carbonates (e.g., siderite), iron silicates (e.g., stilpnomelane) and chert-matrix (chert with any of the other phases). Based on the characteristics of the Dales Gorge Member of the Hamersley Group (Fig. 1), banding in Hamersley Province BIF is classified as 1) macrobands with meter to tens of meters thick layers of alternating BIF and shales, 2) mesobands with internally consistent cm-thick bands of different compositions, and 3) microbands with thin mm-scale bands of iron-bearing minerals commonly within chert mesobands (Trendall and Blockley, 1970). Although all forms of banding have been correlated across the entire Hamersley Province (Ewers and Morris, 1981; Krapež et al., 2003; Trendall, 2002; Trendall and Blockley, 1970), thickness variations of the banding are evident on all scales, and it remains controversial whether these variations are of depositional or tectonic origin.

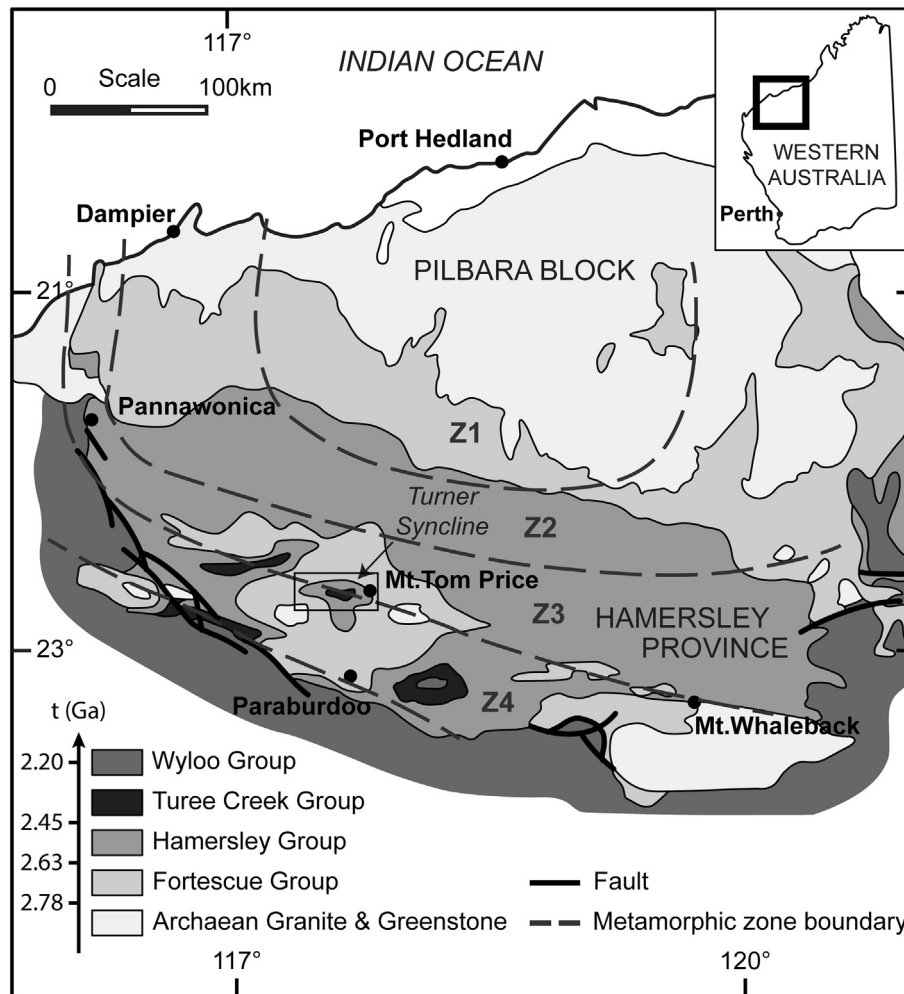


Fig. 1. Overview of the geology and stratigraphy of the Hamersley Province (Western Australia). The central and western part of the Province show a complex fold interference pattern with the Turner Syncline, study area (box; modified after Taylor et al., 2001). Ages (t) are based on Trendall et al. (2004) and metamorphic zones are identified as Z1: prehnite-pumpellyite facies, high zeolite facies; Z2: prehnite-pumpellyite facies; Z3: pumpellyite-actinolite facies; and Z4: greenschist zone (Smith et al., 1982).

Download English Version:

<https://daneshyari.com/en/article/4715451>

Download Persian Version:

<https://daneshyari.com/article/4715451>

[Daneshyari.com](https://daneshyari.com)