Precambrian Research 183 (2010) 749–769

Contents lists available at ScienceDirect

Precambrian Research

journal homepage: www.elsevier.com/locate/precamres

Sedimentary geology of the Palaeoarchaean Buck Ridge (South Africa) and Kittys Gap (Western Australia) volcano-sedimentary complexes

Sjoukje T. de Vries, Wouter Nijman*, Poppe L. de Boer

Sedimentology Group, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 7 May 2010
Received in revised form 1 September 2010
Accepted 22 September 2010

Keywords:
Archaean sedimentary basins
Archean sedimentology
Barberton Greenstone Belt
Coppin Gap Greenstone Belt
East Pilbara granite-greenstone terrane
Chert

ABSTRACT

The two Palaeoarchaean volcano-sedimentary complexes of the Buck Ridge (Barberton Greenstone Belt, South Africa) and Kittys Gap (Coppin Gap Greenstone Belt, East Pilbara, Australia) have a similar geological setting and age (~3.45 Ga). The predominantly volcaniclastic sediments are concentrated at the top of these complexes, and experienced thorough, (very) early diagenetic silicification. In many places the silicification process has led to excellent preservation of the primary sedimentary structures. Elsewhere it has resulted in their obliteration or replacement by diagenetic structures. The Buck Ridge chert forms a regressive-transgressive succession, deposited around base level, with lacustrine and littoral marine facies. Deposition of the Kittys Gap Chert was also close to base level, almost exclusively subaqueous, with tidal influence and a regressive sequential trend.

In both volcano-sedimentary complexes, these low-energy sediments are juxtaposed with high-energy breccia pods and layers, with often a high Fe-oxide content. The breccias are interpreted as being the result of explosive hydrothermal activity. Sedimentation was strongly controlled by normal faulting.

1. Introduction

We discuss two well-preserved Palaeoarchaean silicified sedimentary rock units (cherts), that both form the top of intraformationally faulted complexes of intrusive and extrusive felsic rocks, minor basalts, felsic volcaniclastic sedimentary rocks and sedimentary cherts, further indicated as a volcano-sedimentary complex (vsc):

- the Buck Ridge Chert[1] (BRC[2]) of the ~3.45–3.41 Ga Buck Ridge volcano-sedimentary complex (BR-vsc, uppermost Hooggenoeg Formation, Onverwacht Group), located on the northern limb of a major antiform that affects a large part of the southern Barberton Greenstone Belt (South Africa, Fig. 1).
- the Kittys Gap Chert (KGC) of the ~3.45 Ga Kittys Gap volcano-sedimentary complex (KG-vsc, Panorama and possibly Strelley Pool Formations[3]) in the Coppin Gap Greenstone Belt (Pilbara, Western Australia, Fig. 2).

The BR-vsc and KG-vsc are underlain and overlain by major successions of mostly extrusive mafic to ultramafic rocks.

The exposed length of the BR-vsc is at least 15 km (for a detailed map see Nijman and De Vries, 2009). Apart from minor chert layers in the lower part, the sedimentary rocks are concentrated along the top of the complexes, above, lateral to, and partly alternating with felsic volcanic rocks. In both areas, the felsic volcanic rocks and sediments were deposited concurrent with large-scale normal (growth) fault activity (Nijman and De Vries, 2004; De Vries et al., 2006a,b). The syndepositional tectonism produced pronounced thickness variations across the faults (maximum thickness in the hanging walls; minimum thickness in the footwalls, Figs. 1 and 2), block rotations and roll-over anticlines. The thickness variations decrease upward in the stratigraphic succession.

The felsic lavas and intrusive TTG (tonalite-trondhjemite-granodiorite) rocks of the BR-vsc are 3451 ± 5 Ma old (De Vries et al., 2006a; SHRIMP zircon U-Pb Zr dating[4]), whereas the volcaniclastic rocks were assigned a maximum age of 3416 ± 5 Ma by Kröner et al., 1991; Pb-Pb evaporation dating. Along the southern limb of the Onverwacht Bend, the BRC is either absent (e.g. Viljoen and Viljoen, 1969), or represented by 'three chert layers inter-bedded with thicker volcanic units' (Lowe et al., 1985; Lowe and Byerly, 1999). The volcanic units include massive and pil-

* Corresponding author.
E-mail address: wnijman@geo.uu.nl (W. Nijman).

[1] or Buck Reef Chert (Lowe and Byerly, 1999).

[2] The term BRC is applied from the level where the sedimentary succession has been thoroughly silicified, a transition that is clearly visible on aerial photographs.

[3] The entire KG-vsc was previously considered to belong to the Panorama Fm (e.g., Nijman et al., 1998b; De Vries et al., 2006b; Westall et al., 2006), However, Hickman (2008) considers the KGC to be part of the Strelley Pool Formation, a formation separating the Warrawoona and Kelly Groups, and the felsic part of the KG-vsc as belonging to the Panorama Fm in the top of the Warrawoona Group.

[4] The GPS coordinates of dating sample LV01-23 were mentioned incorrectly in Table 3 of De Vries et al., 2006a. The correct coordinates are: S 25°55′33.6″/E 30°54′07.1″.

0301-9268/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.precamres.2010.09.005

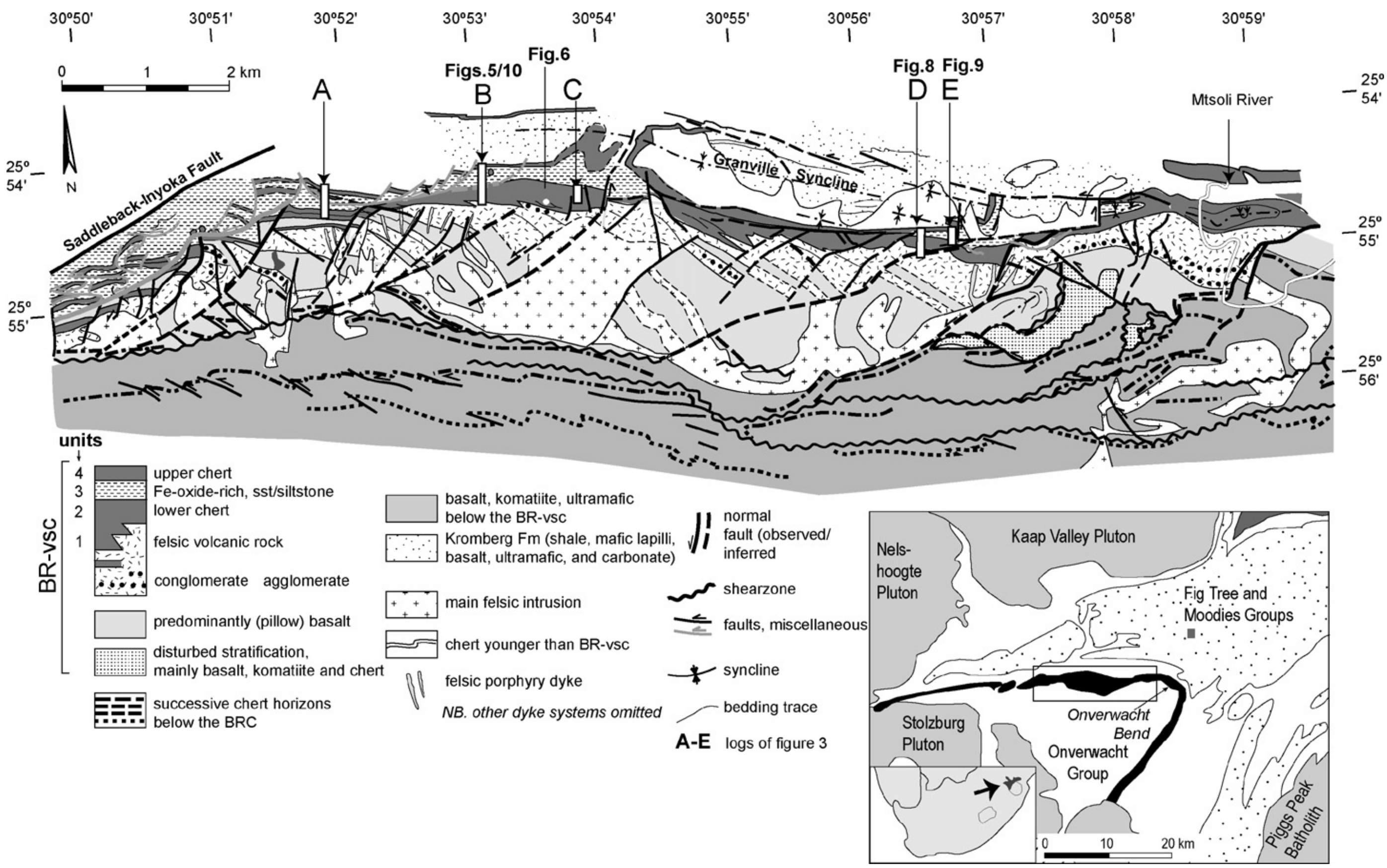

Fig. 1. Geological map of the Buck Ridge volcano-sedimentary complex in the upper Hooggenoeg Formation (map simplified after De Vries et al., 2006a; Nijman and De Vries, 2009; for location in the southern Barberton greenstone belt see the inset). The entire succession has been tilted into a vertical orientation; younging direction is to the north. A–E refers to log locations. Locations of Figs. 5, 6, 8–10 are indicated. Legend applies to the main figure, not to the inset.

low basalts, mafic pyroclastic layers, komatiitic flows and intrusive units.

The sedimentology of the BRC has been the subject of several recent studies: Lowe and Fisher Worrell (1999) described evaporitic facies in the lowermost part of the BRC, Tice and Lowe (2004) described the environment of formation of photosynthetic microbial mats in the BRC, Tice and Lowe (2006) studied the distribution of carbonaceous material in the various chert facies, while De Vries et al. (2006a) focused on the growth-fault controlled architecture.

The KG-vsc is exposed over a length of ∼5 km. The complex is sandwiched between pillow basalts of the underlying Apex and overlying Euro Basalts. The felsic igneous rocks of the KG-vsc have an age of 3446 ± 5 Ma (U-Pb SHRIMP dating, De Vries et al., 2006b). The KGC forms the silicified sedimentary (chert) top of the complex (Fig. 2).

Growth-fault control on the deposition of the KGC sediments was first mentioned by Nijman et al. (1998b), and further elaborated in Van Kranendonk et al. (2001), Nijman and De Vries (2004) and De Vries et al. (2006b). Biological and geochemical aspects of the KGC were described by Westall et al. (2006), Orberger et al. (2006) and Rouchon and Orberger (2008).

In studies of pre-3.3 Ga sedimentary rock units, the link between micro- to mesoscale sedimentological features on the one hand and the overall geological setting on the other hand is still fragmentary. Detailed analysis of the geometry of the sedimentary deposits should help to fill this gap. Therefore, in the facies analysis of this paper, the one-dimensional, vertical variation in the sequential architecture (bedding, grainsize trends, primary and secondary sedimentary structures), and the lateral variation in the geometry of the chert units have been given more emphasis than the detailed sediment petrography. The interpretation of the depositional environment is given in two steps. The first step, consisting of an environmental diagnosis that can be directly derived from the observations, is given immediately after the description of the geometry and facies of each stratigraphical unit. The interpretation of the succession and lateral variation of stratigraphical units, which relate to the basin fill as a whole, are given in summary interpretations for the BR-vsc (Section 2.6) and the KG-vsc (Section 3.4) respectively.

In both areas, silicification has locally led to an excellent preservation of sedimentary textures and structures, which elsewhere have been partly or completely obliterated by the same process. In combination with synsedimentary deformation, this syndepositional to early diagenetic silicification, to an extent hardly known on modern Earth, complicates the interpretation of the sedimentary successions, and is therefore addressed as well (Section 4).

2. Sedimentology of the Buck Ridge Chert and related volcaniclastic deposits

2.1. Stratigraphic subdivision, geometry and structural features

Fig. 1 gives an overview of the extent and distribution of the sedimentary succession at the top of the BR-vsc, including the locations of sedimentary logs A–E (Figs. 3 and 4). Four sedimentary units are distinguished in the BRC. They are particularly well exposed in the central part of the map area (units 1–4; Figs. 1, 4 and 5). Thicknesses of the BRC proper here vary between ∼100 m (footwall thickness) and ∼530 m (hanging-wall thickness). Post-depositional, ∼3.228 Ma pyroxene-amphibole porphyry dykes and sills intruded