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Characterization of Deonar Porcellanites from Sidhi district, Madhya Pradesh

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Abstract

The pyroclastic and volcanogenic deposit of Deonar Porcellanite Formation of Semri Group (Vindhyan Supergroup) represents the records of violent explosive felsic volcanism during late Mesoproterozoic. Five lithounits have been identified in the porcellanites exposed along Amiliya-Bahari section in Sidhi district. Based on the field observations, petrography and other features, three phases of volcanic eruption and sedimentation have been recognized, suggesting a mixed provenance for Deonar Porcellanite.

Introduction

Deonar Porcellanite of Semri Group, Vindhyan Supergroup extends as a linear belt from Palamau district of Bihar in the east and Sidhi district of Madhya Pradesh in west. Deonar Porcellanites form laterally discontinuous small hillocks as strike-parallel chain of ridges for several tens of kilometers. Individual mounds range from 50 to l00m in height and 300m to one kilometer in width. Deonar Porcellanite comprises thinly bedded, fine grained siliceous sediments, felsic volcanic tuffs, tuffaceous shales and sandstones, forming conspicuous outcrops, along the banks and river bed of the Son river in Sidhi district (Fig, 1).

Law (1954) carried out detailed geological investigations in Sidhi district and concluded the porcellanite to be of pyroclastic origin, occurring with siliciclastics like shales, sandstones etc. Ghosh (1971) attributes extensive lateral continuity of these beds is the result of turbidity current based on his study in Sidhi district. Soni et al. (1987) noted the presence of a mineralized fractured zone within the pyroclastic rocks near Sihawal in Sidhi district. They also considered the occurrence of large sized volcanic bombs and lapilli near Rampur as an indication of the proximity of another focus. Rasmussen et al. (2002) and Ray et al. (2002) published precise U-Pb zircon ages of 1628$\pm$8 and 1631$\pm$5 for Deonar Porcellanite. The present paper aims at recognition and characterization of lithounits in Deonar Porcellanites of Lower Vindhyans. The description is based on observations along the classical Amiliya-Bahari section in Sidhi district (Fig, 1).

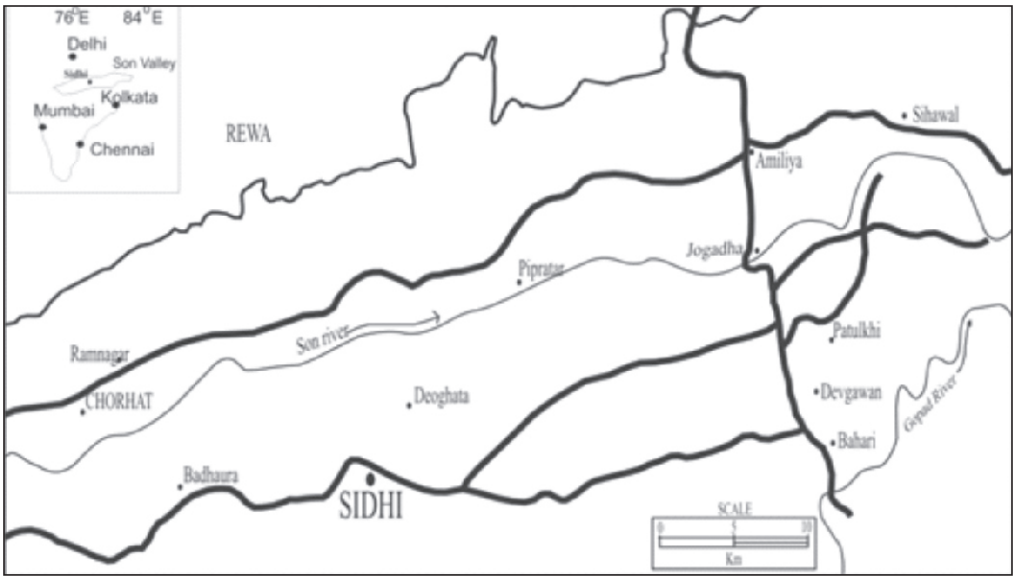

Fig. 1: Map showing location of the study area

Geological Setup

The stratigraphic succession around Sidhi district in M.P. comprises (i) the basement Sidhi granite (ii) Mahakoshal Group and (iii) Vindhyan Supergroup (Table 1). Vindhyan Supergroup has been divided into Lower and Upper Vindhyan, the former comprises Semri Group and the latter includes Kaimur and Rewa Groups. Upper Vindhyan is represented by clastic sediments whereas the Semri Group comprises mainly biochemical sediments with the volcanogenic activities.

The Semri Group unconformably rests over the metamorphosed Mahakoshal Group overlying the basement Sidhi Granite. Sidhi area exposes the oldest rock units of tonalite trondjhemite series formed during proto-continental stage (3.7-2.9 Ga) representing the ancient crust (Roy and Bandyopadhyay, 1990). The evolution of the granitic basement equivalent to Chhotanagpur Granitic Gneissic Complex resulted in the development of magmatic suites represented by migmatites, rhyodacite, alkaline intrusive and highly felspathised gneisses. Mahakoshal Group consists of phyllites, shales, slates with mafic intrusive present as sills and dykes (Sarkar et al., 1998). Preexisting rifted basins led to the deposition of Mahakoshal Group (2.6 to 1.9 Ga), which is classified as Greenstone Belt. The pre-Vindhyan basement embodies the whole tectono-magmatic-sedimentary cycle, which commenced with deep fracturing and emplacement of ultrabasic lavas near the surface, followed by sedimentation and basic volcanic (Yedekar, 1990; Nair et al. 1995; Roy and Devarajan, 2000).

Table 1: Stratigraphic succession around Sidhi district, Madhya Pradesh (after Ramakrishnan and Vaidyanadhan, 2008)

Upper Vindhyan	Rewa Group Kaimur Group	
	Unconformity	
Lower Vindhyan/ Semri Group	Rohtas Limestone Basuhari Sandstone Bargawan Limestone Olive Shale **Deonar Porcellanite** Deoland Sandstone	
	Unconformity	
	Mahakoshal Group	
	Unconformity	
	Sidhi Granite	

Deonar Porcellanite

It consists of silicified pyroclastic rocks that are the records of a violent explosive felsic volcanic activity during the deposition of Lower Vindhyans at 1630 Ma (Rasmussen et al. 2002; Ray et al. 2002). Deonar Porcellanites are composed of thick stacks of pyroclastics and volcaniclastics conformably overlying the hard compact sandstones of Deoland Formation. Porcellanite is overlain by Olive Shale along a conformable contact. These rocks are massive but often show laterally persistent flow layers. Apparently in most instances the porcellanites dominantly exhibits vitroclastic texture and subordinate particulate texture. However there are considerable variations in internal character along and across strike, mainly reflected in the form of presence or absence of very well developed plane parallel banding (mm-scale) and some deformation features.

The porcellanite is dominantly fine-grained and are mineralogically similar, consisting of quartz and feldspar phenocrysts set in a recrystallized mosaic of quartz and feldspar with widely varying amount of devitrified groundmass, sericite, carbonates and Fe-oxides. Petrographic observations attest the pyroclastic origin of the Deonar Porcellanite, indicated by the presence of abundant pumice fragments, delicate glass shards, rhyolitic fragments, deeply embayed quartz grains and cryptocrystalline groundmass. On the basis of welding intensity of ignimbrites, Branney et al. (1992) have further extended the classification into: extremely high-grade ignimbrites (lava-like ignimbrites), high-grade ignimbrite (rheomorphic ignimbrite), moderate-grade ignimbrites that have both welded and non welded zones, and low-grade ignimbrites with no welding and distinct particulate nature.

Porcellanite comprises welded and unwelded ignimbrite as implied by thin section study (Mishra and Sen, 2008). Welded ignimbrite exhibits pumice fragments with tapering ends, welded to each other along the swirling margins by dark brown ferruginous material, referred to as "eutaxitic texture" (Bull and McPhic, 2007). Whereas, unwelded ignimbrite signifies loosely welded volcanic ash beds. They are composed of fragments of angular quartz, broken glass, K-feldspar (Fig. 2), muscovite, biotite, lithic fragments and rarely plagioclase, lying in vitric and cryptocrystalline groundmass.

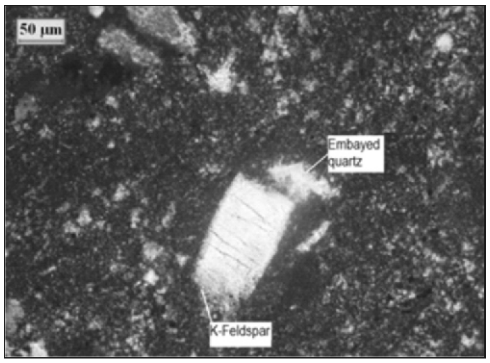

Fig. 2: Fractured and clouded K-Feldspar and embayed quartz in cryptocrystalline groundmass (between cross nicols)

Recognition of lithounits in Deonar Porcellanites

Deonar Porcellanite is dominantly of banded nature with alternating pale and dark bands. The massive varieties are of variegated colors- opaline green, buff, grey, grayish black etc. They also include fine grained tuff, pumice and lapilli fall deposits, volcanic breccias and bombs etc. The tuffaceous layers have been divided into lithounits based on colour, texture, grain size and sedimentary features. On the basis of field observations along Amiliya-Bahari section (Fig. 1), five lithounits namely, Banded Porcellanite, Brownish green unwelded tuff, Opaline green welded tuff, Opaline and coarse grained buff coloured tuff and Opaline and coarse grained grey tuff have been identified and shown in the vertical profile section (Fig.3).

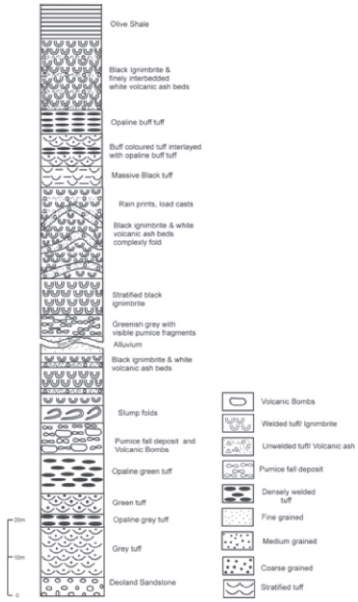

Fig. 3: Vertical profile along Amiliya–Bahari section

i) Banded Porcellanite consists of laterally persistent dark and pale bands of varying thickness ranging from hairline thickness to >30cm. The unwelded volcanic ash beds are of pale colour whereas the welded tuff is represented by dark colour. The lamination in dark and pale banded porcellanite is parallel to the strike of the area. This is the most commonly occurring lithounit of Deonar Porcellanite. Occasionally, the banded porcellanites show elliptical and flattened volcanic bombs of > 50 cm (Fig. 4) occurring parallel to the lamination, within pale coloured bands. Apart from banding, porcellanites often exhibit sedimentary features namely cross lamination, graded bedding, convolute structure, load cast and rain print. Porcellanite shows rhomboidal and columnar joint pattern. Deonar Porcellanite occurs as highly folded into innumerable sharp anticlines and synclines along Amiliya-Bahari section. Banded porcellanite also exhibit soft sediment deformation, possibly due to seismicity during explosive volcanism.

Fig. 4: Elliptical volcanic bomb filled by scoracious material enclosed by pale coloured band of banded porcellanite

ii) Brownish green unwelded tuff is coarse grained with floating elliptical shaped fragments of lapilli. The fragments are not uniformly distributed floating in the matrix of sandy nature. Some beds have more concentration of lapilli fragments (Fig. 5). They are thickly bedded (>200cm) with intervening thin laminations (<8cm). The sedimentary structures encountered are current bedding and load cast. This lithounit is exposed along northern bank of river Son at Jogadha.

Fig. 5: Brownish green tuff showing cross bedding. The arrow on the right side indicates visible lapilli fragments aligned parallel to the bedding.

iii) Opaline green welded tuff is very fine grained, transluscent and medium bedded variety of porcellanites. The fresh surface shows vitreous luster, conchoidal fracture and typical green colour, whereas their weathered off white surface shows waxy luster. This lithounit is well represented at Devgawan.

iv) Opaline and coarse grained buff coloured tuff are exposed at the northern bank of river Son. Opaline buff coloured variety is very fine grained, welded, translucent and thinly bedded variety of porcellanites. The fresh surface shows vitreous lustre and conchoidal fracture, whereas their weathered surface shows waxy luster. Buff colored, coarse grained, thickly bedded tuff (~2.5m) is particulate in nature. There are intervening layers of medium grained (~1m) and fine grained (12-24cm) tuff. Fine grained variety is more siliceous with conchoidal fracture.

v) Opaline and coarse grained grey tuff is very fine grained, thinly bedded, with waxy luster and conchoidal fracture. Grey coloured welded, opaline tuff occurs with green opaline tuff. Coarse grained, massively bedded variety of dark grey tuff is exposed with opaline tuff.

Discussion and Conclusion

Deonar Porcellanite is the expression of explosive felsic volcanic activity in the Lower Vindhyans at the late Mesoproterozoic. Porcellanite based on the field observations in the study area are moderate-grade ignimbrites comprising both welded and non welded zones, and low-grade ignimbrites with no welding and distinct particulate nature. The variation in welding characters and gradation of eutaxitic flow-laminated rheomorphic tuffs from the more particulate flow deposits strongly suggests that the porcellanites in study area are pyroclastic in origin. Discriminating between welded and unwelded tuff is important in understanding the depositional environment and eruptive style (Fisher and Schmincke, 1984; Gifkins et al., 2005). Generation of welding textures requires high temperature during or shortly after deposition, and are thought to be more common with subaerial deposits. However, welding in pyroclastic flow deposits is possible under shallow submarine condition also (Smith, 1960; Fisher and Schmincke, 1984). The explosive eruptions take place when a mixture of pyroclasts and gas are discharged into the atmosphere.

Three distinct phases of volcanic eruption and sedimentation can possibly be deciphered in Deonar Porcellanites, based on lithologic association, grain size, welding and sedimentary structures. The active phases of eruption started under water with ejection of welded ignimbrites and pumice-fall tuff represented by dark bands of banded porcellanites. The active phases were intervened by spells of quiescence depositing ash fall/ dust indicated by unwelded pale bands of banded porcellanitic tuff. The periods of active volcanism and quiescence was also intervened by the sedimentation, evident from low-grade ignimbrites with no welding and their distinct particulate nature. This observation is based on coarse grained granular, green, buff and grey varieties of tuff and associated sedimentary features. This suggests a substantial detrital input together with component that of volcanic origin; mixed origin. These are also associated with their complementary opaline varieties, suggesting them to be medium grade ignimbrite. Deonar Porcellanites probably represents the amalgamation of episodes of active volcanism, periods of quiescence (ash/dust fall) and normal sedimentation without any marked hiatus.

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