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# Geochemistry of Acid Volcanics of the Dalma Group, Singhbhum, Eastern India

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**The earlier mapped chert to the north of the Dalma range is indeed a fine tuff characterised by the presence of spherulites, vesicles, amygdales, pele's tears. These rocks are silicified, peraluminous acid volcanic rocks.**

The Dalma Group of Eastern India occurs in a 200 km long and 4 km wide arcuate belt, the Dalma range (Fig.1). Although the mafic-ultramafic volcanics of the Dalma Group have been studied in great detail, its silicic components remained unattended. The silicic rocks exposed to the north of the Dalma range were earlier mapped as cherts. Though Chandra and Ahmed (1993) reported rhyolite and acid tuff from Chandil area, no petrographic or other details of these rocks are available. The petrography and geochemistry of the felsic volcanics exposed to the north of the Dalma range are presented here.

**Geological Setting:** The metavolcanics of the Dalma Group conformably rest over the metapelites of the Chaibasa Group. This group occupies core of the Dalma range and also occurs to the north and west (Fig.1). These two groups belong to the Lower Proterozoic

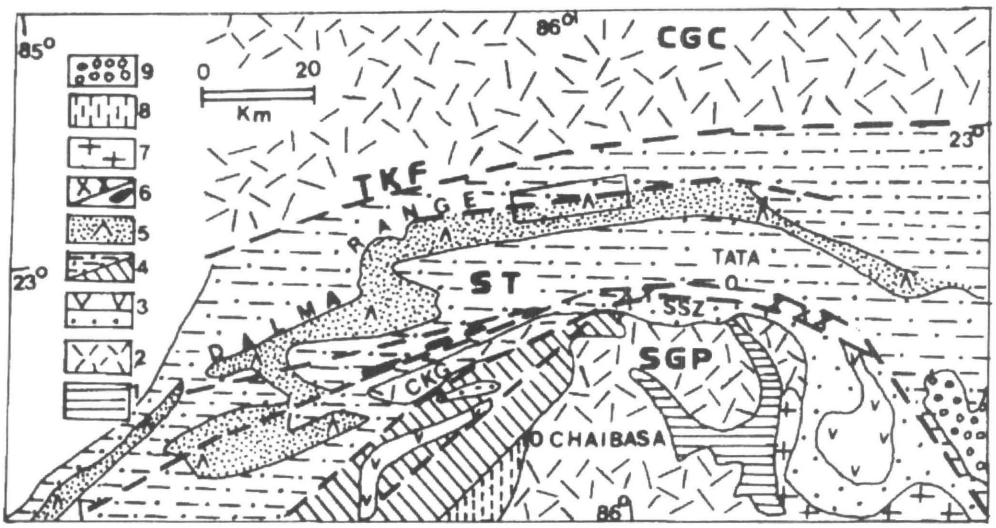


**Fig.1.** Geological map of the Dalma range and adjacent area. 1. Iron Ore Group of Gorumahisani, 2. Older granitoids, 3. volcanics/metasedimentaries- Dhanjori Group, 4. Chaibasa/Iron Ore Group of Noamundi, 5. Dalma Group, 6. Soda granite/granophyre, 7. Mayurbhanj granite, 8. Kolhan Group, 9. Tertiary gravels, T.K.F. - Tamar-Khatra Fault, SSZ - Singhbhum. Shear Zone. CGC- Chotanagpur Gneiss Complex, SGP- Singhbhum Granite Platform, CKG-Chakradharpur granite. Inset rectangular area is enlarged in Fig .2.

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Singhbhum Supergroup. The Dalma Group is classified into two units. The lower unit is characterised by high magnesian pyroclasts with lenses of pyroclastic conglomerates. The upper unit is composed of metabasalts with thin lenses of basic agglomerates (Fig.2). These rocks are intruded by peridotite and serpentinite.

The mafic pyroclasts of the northern limb of the Dalma syncline enclose layers of medium- to coarse-grained felsic tuffs which register an increase in thickness and population and reduction in grain-size towards north and finally the entire sequence grades to grey, massive to finely-laminated, very fine-grained felsic tuff (Fig.2). These pyroclasts preserve a variety of sedimentary structures indicating their deposition under shallow-water condition. Quartzite interbeds show effects of reworking. Uniform composition and texture of the fine-grained rocks over a large area characterise airborne subaqueous deposits. Available field evidences are compelling to suggest that these tuffs are eolian differentiated subaqueous distal facies of subaerial volcanism.

**Petrography:** Megascopically, the felsic tuffs are massive to finely laminated and micro-laminated (Fig. 3), very fine-grained, grey to dark grey and at places glassy. Conchoidal

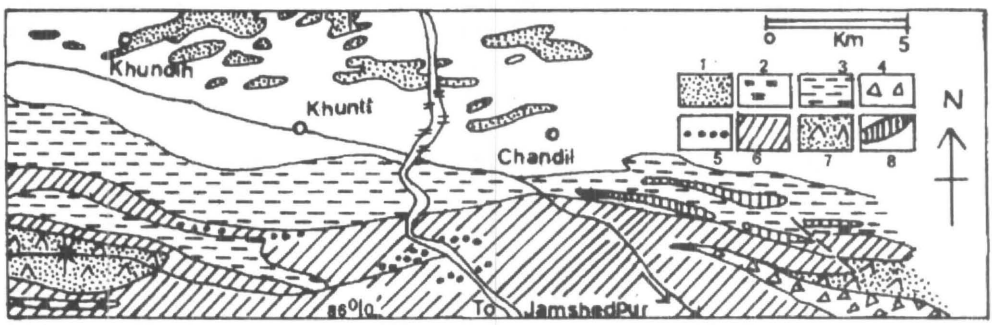
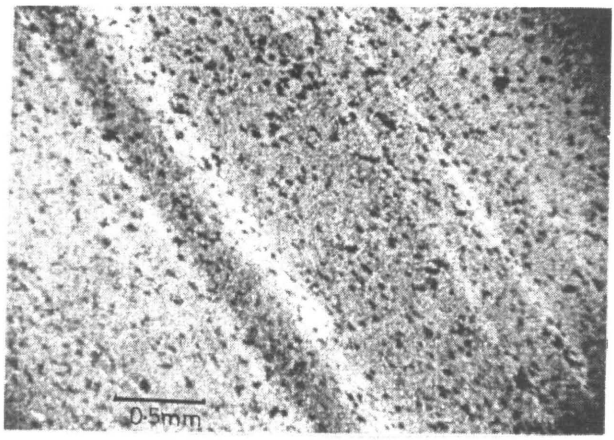



**Fig.2.** Geological map of Chandil-Khundih area (modified after Gupta *et al.* 1980): 1. Felsic tuff, 2. interbedded mafic-felsic tuff with thin bands of phyllite, quartzite, and carbonate, 3. carbonaceous phyllite with bands of tuff and quartzite, 4. mafic agglomerate, 5. mafic lapilli tuff, 6. mafic-ultramafic tuff, 7. basalt, 8. gabbro-pyroxenite.

fracture is a characteristic feature. Vesicles and amygdales are occasionally seen. Pele's tears and euhedral feldspar have been recorded in some parts. Megaspherulites (Fig. 4) are profusely developed in Khundih area (Fig . 2). Very fine-grained cherty tuff is flow-banded and autobrecciated (Fig.5).

The tuffs are composed of yellowish to brownish xenocrysts of biotite, quartz, feldspars, iron oxides and rarely euhedral garnet set in glassy to very fine-grained matrix of quartz, sericite, chlorite, feldspars, glass and epidote. Anhedral to euhedral prismatic grains of carbonate showing lamellar twinning are seen in some parts whereas long, slender, prismatic to needle like crystals of diagenetic tourmaline are distributed throughout the rock in almost all the sections. Biotite is mostly anhedral and invariably shows effect of magmatic resorption. Alteration to chlorite along cleavage and grain margins is common. Both K-feldspar and plagioclase are sericitised. Quartz phenocrysts are triangular, wedge-shaped, rounded, fractured and at places embayed. Glass is generally white, devitrified and occurs as fine drops, lenticles and irregular patches. Epidote occurs in clusters or in fine layers

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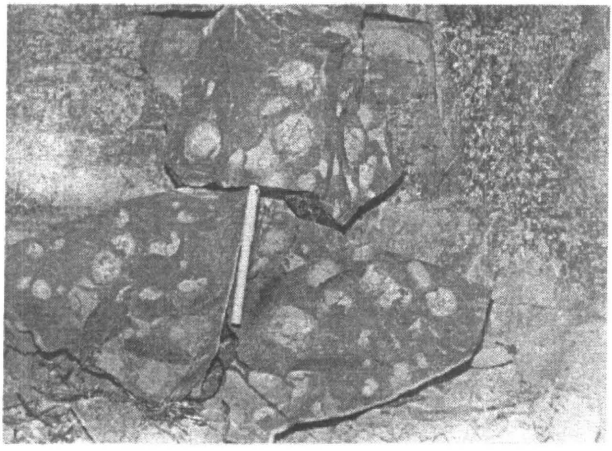

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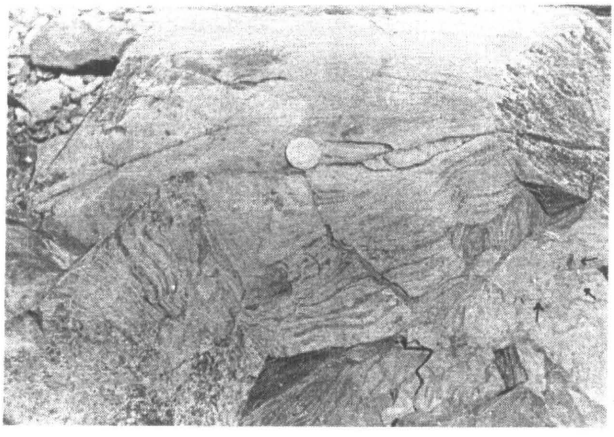

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**Fig.3.** Photomicrograph showing microlamination in felsic tuff, Khundih; PPL.
**Fig.4.** Megaspherulite in very fine-grained tuff, south of Khundih.
**Fig.5.** Flow-banded and autobrecciated tuff. Note lava drops and feldspar euhedra in lower right (arrow), south of Khundih.

alternating with felsic material, possibly defining micro flow layers. Flow feature is also indicated by linear to sigmoidal arrangements of crystallites. Apatite is main accessory mineral. Rounded to elliptical and also irregular patches with diffused outline, composed of comparatively finer-grained, equigranular quartz and rare feldspar with needles of sericite and chlorite are considered to be pele's tears. Some drops show only radiating green crystallites. Vesicles are filled with natrolite, carbonate, opaques, chlorite, epidote and quartz. Fine veinlets of quartz/quartz-muscovite/quartz-chlorite are also present.

**Geochemistry:** Ten samples representing different stratigraphic levels were analysed for major and trace elements at the Chemical Laboratory, Eastern Region, GSI, Calcutta. Major elements were analysed by X-ray fluorescence spectrometer; FeO and L.O.I by wet chemistry, and, trace elements by Emission Spectrograph and Atomic Absorption Spectrophotometer.

**Table I.** Chemical analysis of felsic volcanics of the Dalma Group, Singhbhum, Eastern India.

| Sl.No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sam.No. | 5/94 | 8/94 | 12/94 | 15/94 | 26/94 | 27/94 | 27/94 | 30/94 | 33/94 | 35/94 | - | - |
| $SiO_2$ | 76.17 | 77.55 | 70.67 | 69.10 | 74.92 | 73.70 | 75.46 | 65.14 | 80.10 | 76.92 | 73.97 | 72.82 |
| $Al_2O_3$ | 12.61 | 12.23 | 15.05 | 15.97 | 14.57 | 12.72 | 11.39 | 15.99 | 9.94 | 13.43 | 13.19 | 13.27 |
| $Fe_2O_3$ | 1.01 | 0.92 | 1.48 | 2.95 | 1.27 | 0.73 | 0.10 | 5.98 | 0.98 | 0.64 | 1.59 | 1.48 |
| FeO | 0.99 | 1.17 | 1.98 | 1.35 | 0.90 | 1.17 | 4.32 | 0.90 | 1.08 | 0.63 | 1.45 | 1.11 |
| MnO | 0.04 | 0.04 | 0.05 | 0.04 | 0.05 | 0.02 | 0.03 | 0.09 | 0.04 | 0.02 | 0.04 | 0.06 |
| MgO | <0.15 | L0.15 | 1.03 | 1.20 | 0.22 | 0.34 | 0.57 | 1.86 | 0.22 | <0.15 | 0.57 | 0.39 |
| CaO | 0.20 | 0.60 | 0.38 | 0.31 | 0.42 | 0.21 | 0.42 | 0.63 | 0.34 | 0.21 | 0.37 | 1.14 |
| $Na_2O$ | 1.24 | 1.23 | 1.11 | 1.05 | 4.18 | 1.21 | 0.68 | 1.65 | 0.96 | 2.17 | 1.55 | 3.55 |
| $K_2O$ | 6.33 | 5.53 | 6.98 | 4.79 | 2.50 | 8.39 | 4.51 | 4.35 | 5.25 | 4.16 | 5.28 | 4.30 |
| $TiO_2$ | 0.21 | 0.21 | 0.33 | 0.62 | 0.21 | 0.23 | 0.36 | 0.71 | 0.19 | 0.29 | 0.34 | 0.28 |
| $P_2O_5$ | 0.01 | <0.01 | 0.04 | 0.02 | <0.01 | 0.03 | 0.11 | <0.07 | <0.01 | <0.01 | <0.03 | 0.07 |
| LOI | 0.67 | 0.73 | 1.18 | 2.32 | 0.45 | 0.54 | 1.31 | 1.60 | 0.45 | 0.51 | 0.98 | - |
| Total | 99.48 | 100.26 | 100.28 | 99.73 | 99.52 | 99.29 | 99.26 | 99.97 | 99.55 | 99.98 | 99.36 | 98.47 |
| $Fe_2O^t$ | 2.10 | 2.22 | 3.68 | 4.46 | 2.12 | 2.03 | 4.90 | 6.98 | 2.18 | 1.34 | 3.20 | 2.71 |
| Trace elements in PPM | | | | | | | | | | | | |
| Cu | 30 | 10 | 25 | 45 | 05 | 15 | 45 | 20 | 10 | 10 | | |
| Pb | 45 | 35 | 65 | 30 | 35 | 35 | 45 | 30 | 30 | 20 | | |
| Zn | 40 | 55 | 65 | 65 | 55 | 40 | 110 | 70 | 35 | 25 | | |
| Ni | <20 | <20 | <20 | 35 | <20 | <20 | 60 | 20 | <20 | <20 | | |
| CO | <20 | <20 | <20 | <20 | <20 | <20 | 25 | <20 | <20 | <20 | | |
| Cr | <20 | 20 | 30 | 130 | 125 | 20 | 90 | 50 | <20 | <20 | | |
| Li | 10 | 10 | 20 | 15 | 10 | 15 | 25 | 25 | 10 | 10 | | |
| Rb | 150 | 170 | 215 | 165 | 65 | 190 | 190 | 165 | 240 | 75 | | |
| Sr | 65 | 65 | 55 | 45 | 70 | 70 | 50 | 45 | 70 | 50 | | |
| Ba | 1300 | 1000 | 515 | 600 | 340 | 625 | 340 | 945 | 805 | 685 | | |
| V | <10 | <10 | 10 | 50 | <10 | <10 | 70 | 10 | <10 | <10 | | |
| Y | <10 | 10 | 10 | <10 | 10 | 10 | <10 | 10 | <10 | 10 | | |
| Zr | 100 | 50 | 50 | 150 | 100 | 150 | 50 | 100 | 50 | 100 | | |
| Nb | <30 | <30 | <30 | <30 | <30 | <30 | <30 | <30 | <30 | <30 | | |
| Yb | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | | |
| $Zr/P_2O$ | 51.00 | 0.5 | 0.125 | 0.75 | 0.10 | 0.5 | 0.045 | 0.14 | 0.5 | 1.0 | | |
| $Zr/TiO_2$ | 0.05 | 0.02 | 0.024 | 0.024 | 0.05 | 0.07 | 0.014 | 0.01 | 0.03 | 0.035 | | |
| Rb/Sr | 2.30 | 2.60 | 3.90 | 3.66 | 0.93 | 2.70 | 3.80 | 3.66 | 3.40 | 1.50 | | |

Sl.No. 1-10 Dalma Volcanics, 11. average of 1-10, 12. average of 670 typical rhyolite ( Le Maitre, 1976).

High content of Ba (300 to > 1000 ppm, average 620 ppm) and Zr (average 91 ppm) support volcanic origin of these rocks.

Although the average major element results of the Dalma felsic volcanics compare well with the average unaltered rhyolite of Le Maitre (1976), except showing depletion in alkalies and CaO, individual values indicate mild to significant enrichment in silica. $K_2O$ shows negative correlation with total $Fe_2O_3$ whereas $Na_2O$ remains constant. This supports loss of sodium due to hydrothermal alteration, which is mild as suggested by enrichment rather than depletion of $K_2O$.

In the total alkali-silica diagram of Le Bas *et al.* (1986) majority of the samples fall in rhyolite and only two in dacite. They are peraluminous with molecular $Al_2O_3$ > $Na_2O+K_2O+CaO$ and have normative corundum. Rb concentration with respect to Y+Nb values (Table I) together with low concentration of $TiO_2$, Nb and Y and high Zr/Nb ratio favour volcanic arc tectonic environment. Sr concentration is low and Rb/Sr ratio variable ranging from 0.93 to 3.90.

**Discussion:** This new find conclusively proves the bimodal character (basalt - rhyolite) of the Dalma volcanics with a distinct gap of over 10 percent in $SiO_2$ concentration. Geochemistry of the ultramafic-mafic suite favour ocean floor (Gupta *et al.* 1980) or ocean back arc setting (Bose and Chakraborti, 1994) for the Dalma volcanics. However, absence of calc-alkaline suite in this belt and predominance of mafic-felsic bimodal suite are more favourable for a continental and extensional tectonic environment. Subaerial to shallow-water deposition of the pyroclasts, and the absence of submarine canyon deposits, debris flow/ mass flow deposits or turbidites, preclude the possibility of arc-related depositional scenario and favour low-gradient, shallow-water continental setting. It is quite likely that the Dalma volcanics erupted in extensional rift-basin having attenuated continental floor which favoured oceanic geochemical signature.

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*Director General (1979)*
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