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EARLY PRECAMBRIAN CRUSTAL EVOLUTION IN EASTERN INDIA: THE AGES OF THE SINGHBHUM GRANITE AND INCLUDED REMNANTS OF OLDER GNEISS.

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Extended Abstract.

The Singhbhum granite batholith complex covers an area in excess of 10,000 sq.km. on the border of the states of Bihar and Orissa in Eastern India (1). The oldest plutonic rock-units recognized within the complex are gneissic remnants, ranging in composition from biotite-tonalite to granodiorite. The gneissic remnants are quite numerous, and may be up to 1000 sq.km. in area. These tonalitic and granodioritic gneisses are assigned to the OMG (older metamorphic group), together with the metasediments and metabasics into which they were synkinematically intruded (1).

Basu et al (1) have reported a Sm-Nd whole-rock isochron date of 3775 +/- 89 Ma on OMG tonalitic and granodioritic gneiss samples from two separate areas within the Singhbhum granite batholith complex, near Champua and Onlajori. Their result is the oldest age yet claimed for rocks from the Indian sub-continent, and is amongst the oldest ages claimed for any terrestrial rock-unit. Basu et al (1) also reported an initial 143-Nd/144-Nd ratio of 0.50798 +/- 0.00007 for the OMG gneisses, corresponding to an initial ϵ(Nd) value of +3.3 +/- 0.9 units (2 sigma errors), unusually high in comparison with most other early Archaean cases (2), although an identical initial ϵ(Nd) value has been reported for 3.5 Ga amphibolites from Qianan County, eastern Hebei, China (3).

The claim of an early Archaean age for the OMG gneisses is clearly a very important development, and a high initial ϵ(Nd) value in early Archaean rocks has major implications bearing on the geochemical evolution of the crust-mantle system: a source for the OMG gneisses with a history of long-term LREE-depletion pre-3.8 Ga would be indicated, and also the existence of a long-lived complementary reservoir with LREE-enriched character. [See ref.(3) for a discussion of the implications of high positive ϵ(Nd) values in early Archaean rock-units.] It is therefore important to seek evidence to confirm the results and interpretations put forward by Basu et al (1).

First, a review of the published Sm-Nd data on the OMG gneiss samples used to construct the 3775 Ma isochron (1) can be made by examining the Nd isotopic evolution of individual samples in a diagram of ϵ(Nd) versus Time. Seven of the nine OMG samples, those with the lowest Sm/Nd ratios, have Nd isotopic evolution lines which intersect DePaolo's (4) empirical depleted mantle [DM] growth curve over a very small age range from 3.52 Ga to 3.45 Ga [i.e. they have T-DM model ages (4) of 3.52 to 3.45 Ga.] The two other samples are less enriched in LREE, and they have lower T-DM model ages of 3.27

and 3.30 Ga. This difference suggests either that these two samples may be younger phases, entirely unrelated to the main group, or perhaps more likely, that they are related rocks, but with later added component(s). It could be significant that both the Onlajari and Champua tonalitic gneisses have been invaded by abundant perthite-muscovite pegmatites (1). On either of these interpretations, there are grounds for concern that the 3775 Ma line might be an artefact resulting from combining materials of different ages for an isochron determination. The Sm-Nd model ages [T-DM] strongly suggest that none of the analysed OMG gneisses is actually as old as 3775 Ma.

Three additional samples of OMG gneisses from other localities within the Singhbhum granite batholith complex [kindly made available to us by S.N.Sarkar and A.K.Saha] give T-DM model ages of 3.41, 3.39, and 3.35 Ga, slightly younger than the model ages discussed above. Two samples of the Singhbhum granite [also supplied by S.N.Sarkar & A.K.Saha] give essentially identical T-DM model ages of 3.36 and 3.40 Ga. From this we conclude that the crustal residence ages of OMG gneisses and the main intrusive phases of the Singhbhum granite are very similar.

The disparity between the 3775 Ma Sm-Nd OMG gneiss isochron result and the ca. 3200 Ma Rb-Sr whole-rock isochron result reported by Sarkar et al (5) for the same suite of samples also merits attention. Basu et al. (1) offered two possible explanations: in their preferred model, formation of the OMG occurred at ca. 3800 Ma, followed by metamorphic resetting of Rb-Sr whole-rock systems at ca. 3200 Ma. However, if the T-DM model ages above are accepted as a reliable constraint on the crustal residence age of the OMG gneisses, the discrepancy between Sm-Nd and Rb-Sr age estimates is greatly diminished. The low initial 87-Sr/86-Sr ratio of ca. 0.7018 for the OMG gneisses in the Champua area (1,5) can also be considered as evidence against long crustal residence prior to 3200 Ma for the precursors of these rocks.

In a study of OMG gneisses provided by S.N.Sarkar & A.K.Saha, we have also obtained a Rb-Sr whole-rock isochron age of 3280 +/- 130 Ma, together with an initial 87-Sr/86-Sr ratio of 0.701 +/- 0.001 [2 sigma errors; 7-point isochron with MSWD 3.7] (Oxford unpublished data; 6). A Pb/Pb whole-rock isochron for the OMG gneisses gives an age of 3378 +/- 98 Ma, and a model $\mu 1$ value of 8.01 [7-point isochron with MSWD 1.1] (6). Thus, comparison of Sm-Nd model ages [T-DM], and Rb-Sr and Pb/Pb whole-rock isochron ages for the OMG gneisses analysed at Oxford shows good agreement, within the limits of analytical error. Furthermore, the low initial 87-Sr/86-Sr ratio of 0.701, the model $\mu 1$ value [source 238-U/204-Pb ratio] of 8.01 for these rocks, and their Nd isotopic compositions at ca. 3.35 - 3.4 Ga, typical of a depleted mantle source at that time, all strongly suggest that the OMG gneisses represent continental crust newly generated at ca. 3.35 - 3.4 Ga.

For the Singhbhum granite, a Pb/Pb isochron yields an age of 3292 +/- 51 Ma and a model $\mu 1$ value of 7.97 [8-point isochron with MSWD 2.5] (6). The T-DM model ages [3.36 & 3.40 Ga] for Singhbhum granite samples imply that their protoliths were extracted from the mantle at the same time as OMG gneisses. The Pb/Pb isochron ages of Singhbhum granite and OMG gneisses are also closely similar. Thus the chronology of events in the development of the Singhbhum granite batholith complex is not yet adequately resolved by isotopic dating. At this stage it must depend principally on critical field observations of structural and intrusive relationships between the constituent rock bodies of the complex. What is clear from the isotopic evidence is that the interval of time separating the formation of the earliest recognized plutonic phases of the Singhbhum granite batholith from the main phases of granite intrusion was not great: Sm-Nd model ages indicate up to ca. 150 Ma, not ca. 600 Ma as previously suggested (1).

The Singhbhum granite and its included gneissic remnants do constitute some of the oldest continental crust yet recognized within India. [Gneisses of similar age are known from the Gorur - Hassan area in the Karnataka Craton of South India. (7) & R.D.Beckinsale, pers. comm.] However, the claim of an age as great as 3775 Ma must be regarded with very serious reservations. Furthermore, the high initial ϵ(Nd) value of +3.3 from the OMG Sm-Nd study (1) should not be used in support of very early separation of LREE-enriched [continental?] crust from the upper mantle, or as evidence of a complementary early LREE-depletion of the mantle. The initial ϵ(Nd) value from the OMG "isochron" is most probably, like the high apparent age of 3775 Ma, an artefact resulting from the inclusion in the isochron set of two samples containing younger component(s) less enriched in LREE than the main group of OMG gneisses.

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