THE NINTH INTERNATIONAL KIMBERLITE CONFERENCE, FRANKFURT, GERMANY

International Kimberlite conferences are held once in 4-5 years interval to discuss advances made in the study of these interesting and economically important rocks. Since its first meeting held at Cape Town in 1973, the conference themes were centered around all aspects of kimberlites and diamonds with emphasis on the origin and evolution of kimberlites and related magmas, their emplacement patterns and mechanism, mantle petrology, cratonic roots, diamond exploration strategies and techniques, target area selection, mining and sustainable developments. The themes attract both industry and academia and therefore, conferences are a great success. On earlier occasions conferences were held at South Africa (twice), Brazil, United States, Siberia, France, Australia and Canada. This series of meetings represent one of the most sought after events in the geological calendars of the last few decades. The ninth in the series was held between 11th and 15th August, 2008 in the historic I.G. Farben Building, Johann Goethe University, Frankfurt, Germany.

In their welcome note, the conference organizers Gerhard Brey and Heidi Hofer expressed that in view of enhanced demand for diamond today there is a need for more sophisticated exploration and analytical techniques, diamond potential forecasts and diamond mining technologies. It also increases the need to know where and how diamonds grew and how they survived the transport to the earth's surface and on earth's surface. They expressed hope that the presentations in this seminar would be able to answer some of the nagging questions in diamond exploration and research.

A total of 93 oral presentations and 278 poster presentations contributed by 740 authors were made during the conference.

The Major Contributions

Large number of presentations churned out an unprecedented large data on the potassic ultramafic rocks of the world. But what are the newer ideas and concepts emerged regarding the kimberlite magmas, their ascent and emplacements or newer diamond and kimberlite discoveries made since 8IKC? It is difficult to select from a plethora of excellent presentations. A few of the papers that appealed are listed here.

The most rewarding one, as singled out by H. Read in the inaugural invited talk, is the 603 carat Lesotho Promise diamond recovered in August 2006 from Gem Diamonds Limited's Letseng le Terai Mine in the northeastern highlands of the Kingdom of Lesotho. The finished flawless polished gems ranging from 0.55 to 75 carats, with a total weight of 224 carats is expected to sell for in excess of $25 million. New kimberlite discoveries reported are (i) Kuusamo, northern Finland (ii) Batain, Oman, (iii) Saptharishi, India (iv) Nanuq, Western Churchill Province, (v) northern Europe, (vi) southeast Guinea and (viii) Zimny Berg. Though geophysical exploration (both aeromagnetic and ground geophysics), geochemical soil surveys and kimberlite indicator mineral (KIMS) continue to dominate the exploration programmes, there were papers that showed fine tuning of these exploration techniques. High resolution ground geophysics involving a loop-loop frequency domain electromagnetic (EM), gravity, magnetic and magento-telluric (Natural Source Audio Magneto telluric) techniques were used for delineating the newer bodies. Two papers (Barbara Scottsmith, Field, M.) addressed economic consequence of emplacement pattern of the kimberlites and demonstrate that olivine data can be used, together with geology and petrography, in the economic evaluation of primary diamond deposits to improve the prediction of diamond grade and distribution within, and between, kimberlite units for resource estimates and to prioritize evaluation work. Rutile has been now added to be list of KIMS (D. Smythe and Co-workers). Among the geochemical anomalies, Nb anomaly has gained its importance in delineation of sub-surface kimberlite bodies (Masum and co-workers). Elusive primary source rock for the high quality gravel diamonds continued to haunt the exploration geologist and therefore such papers as 'headless placers and the search for buried bodies' (problem similar to the Krishna River placer) were presented from Africa (D. Phillips and J.W. Harris) and Algeria (Kahoui and co-workers). Trace elements in garnet is reported as good indicators of diamond grades (Melton and co-workers). Litho-spheric thickness is conjectured to have bearing on the diamond contents in kimberlites (C. Hatton). Through the analysis of micro-inclusions in diamond, it was demonstrated that fluids of different compositions are responsible for successive generations of diamond growth and simultaneously supplied the carbon and that diamonds are secondary minerals formed by metasomatic processes in continental lithospheric rocks at specific times in earth history (T. Stachel and co-workers). These diamond-forming events can be correlated with major tectonic events in the lithosphere. H. Jelsma explained that triggering of kimberlite magma is due to tectonic change - stress change induced within the continental plate because of supercontinent fragmentation (or late orogenic collapse, 520 Ma), and changes in the direction and velocity of plate motion.

There were papers on such subjects – kimberlite volcanism and physics of eruption (Kjarsgaard and co-workers) chlorite-rich (salty) kimberlite of the Udachnaya-East pipe (Yakutia, Russia, Kaminsky and co-workers), on the nature of kimberlite melts, rocks and magmas (R.S.J. Spark and co-workers), on integrated model for Kimberlite ascent and eruption (J.W. Head and R. Wilson), on mineralogical characteristics of tuffisitic kimberlites (R.H. Mitchell) and on genetic links between diamonds and carbonatites in the deep lithosphere (W.L. Griffin and co-workers). A paper on "The hypothesis of impact origin of diamonds and kimberlites" (A. Lyukin) echoed the view published for the Majhgawan lamproites and diamonds in the pages of this journal (Nov. 2006). There were reports on 'super-deep' diamonds (Kaminsky and co-workers), 'ultra-deep' diamonds (Bulanova and co-workers) from

Participants at the 9th International Kimberlite Conference, Frankfurt, Germany.

Brazil and ultra-high pressure macro-diamonds from Bingora (Eastern Australia) and Cempaka, Kalimanton, Indonesia (L.Farun and co-workers)

A few of the nagging debates continued from the 8 IKC. One among these is the utility of the whole rock chemical data for the kimberlite classification and genetic interpretations. Some papers (for example M. Patterson and co-workers) not only reiterated the utility of whole rock data but also demonstrate the association of the highest diamond grades in kimberlites with the highest Mg# and lowest Ti contents which is thought to reflect the greater abundance of highly refractory harzburgite in such kimberlites, coupled with the preferential development of diamonds in highly refractory mantle lithosphere

A new classification of kimberlites was presented (Barbara Scottsmith and co-workers) which focused on volcanic terminology and how it can and should be applied to kimberlite. The nomenclature approach outlined in this paper provides a sound basis for the development of geological models required for kimberlite exploration, evaluation, resource classification and mining

A large number of oral and poster presentations made relates to dating by Re-Os isotopes from inclusions in diamond. A detailed paper (R. Rudnik and R.J. Walker) on its applicability cautioned using Re-Os data without adequate background information.

Indian Contributions

India was represented in the conference by R.H. Sawkar (Geological Society of India), Fareeduddin (Geological Survey of India), Biplob Chatterjee, A.V. Sthapak and I. Ray (Rio Tinto Exploration India Ltd), S. Joy (De Beers India), Rajesh Srivastav and N.V.Chalapathi Rao (Banaras Hindu University), E.V.S.S.K. Babu (NGRI, Hyderabad), Datta Mainkar (DMG, Raipur) and Prof. S.J. Patel (IIT, Mumbai). Mahesh Anand, K.C. Mishra (Cambridge) and Ms. Mani Mala (Diamond Exploration Company).

The highlight of the Indian presentation was the reporting of a cluster of seven diamondiferous pipes christened as Saptharishi Cluster by a team of Rio Tinto Exploration Geologists. The paper provides outline of exploration history in this region which initiated with the identification of two anomalous catchments with Diamond Inclusion Field (DIF) chromite as the most abundant indicator mineral recovered, and lherzolitic pyrope and diamond present in a few samples. Follow-up work involving ground magnetics, soil sampling and prospecting led to the discovery of outcropping source rock adjacent to a coincident magnetic high and Nb soil anomaly. The target (subsequently named Atri), intersected lamproite beneath several meters of colluvium in the vertical discovery hole. A total of seven lamproite bodies emplaced into the Vindhyan Kaimur Group are subsequently identified in the cluster. The Atri occurrence, largest in the cluster has an aerial extent of ~750 x 250 m. It is dated at 1064±15 Ma by Rb-Sr method which is broadly consistent with the ~1100 Ma Majhgawan and Hinota pipes, that occurs 80 km ENE of Saptharishi. The geology and petrography of the Atri pipe shows similarities to the Majhgawan pipe. The discovery of this cluster by Rio Tinto has opened up new vistas for diamond exploration in Vindhyan Basin.

Datta Mainkar and co-workers have produced new geochemical and isotopic data that suggest the Behradih and Kodomali kimberlitic rocks are Group-II kimberlites, a conclusion arrived earlier in a paper in this journal earlier (July, 2006). A paper by R K Srivastava et al. on the lamproites of Damodar valley infer a substantial melt component from the subcontinental lithospheric mantle (SCLM) and suggests a minimal contribution from the convecting (asthenospheric) mantle. Kerguelen mantle plume is inferred to have only superimposed its isotopic signature on these rocks' mantle source regions and provided the heat but not a significant melt component.

There were ten papers on the south Indian kimberlite occurrences. The geochemical study of Siddanpalli Kimberlites by N.V. Chalapathi Rao and his co-workers suggests a mixed chemical signature, different from the other EDC kimberlites, and they attribute this to a combination of factors involving (i) higher degrees of partial melting, (ii) possible involvement of subducted component in their mantle source region and (iii) previous extraction of boninitic magmas from their geological domain. S.C. Patel and his co-workers have suggested that trace elements and REE in Wajrakarur kimberlites are consistent with derivation by extensive partial melting of metasomatised mantle as the La and Yb abundance are essentially direct reflections of the La/Yb ratios of the source regions and not the result of liquid-crystal fractionation. B. Chatterjee and his co-workers have provided petrographic and geochemical data of the Khaderpet kimberlite– carbonatite pipe and infer it to a late-stage fractionation product of the Khaderpet diamond-bearing ultramafic magma which can evolve to produce a rock with all the chemical and petrological characteristics of a carbonatite with an associated widespread aureole of fenitisation. The study on eclogitic xenoliths in Wajrakarur and Kalyandurga kimberlites by E V S S K Babu and his team has led them to conclude that: (1) these represent a variety of protoliths entrained in kimberlites from distinct horizons of the SCLM sections. (2) High Mg# bimineralic deeper eclogites could possibly represent picritic trapped melts. (3) The crustal component observed in the eclogite xenoliths could possibly be derived from the WDC. (4) The eclogite xenoliths show extensive Ba metasomatism with the presence of barite and rare celsian. Babu and co-workers in another paper have reported a combined U-Pb and Lu-Hf isotopic study on the megacrystic zircon xenocrysts from the Kalyandurg-4 kimberlite. They obtained two sets of concordant ages 1097 + 5.7 Ma (MSWD=0.92) and 1154 + 5.1 (MSWD= 0.105) for the analysed KL-4 kimberlite zircons. Both the age estimates fall within the limits established for the other kimberlite clusters of the Dharwar Craton. M Anand and his group presented three papers the first one addressed the current debate relating to contemporaneous or non-contemporanuous emplacements of the kimberlitic magmas in Wajrakarur and Narayanpet fields by performing *in-situ* U-Pb dating of perovskites from a number of kimberlites from this region using the SHRIMP method. Their study has suggested a $^{206}Pb/^{238}U$ age of 1156 ± 32 Ma (2σ) which

is in agreement with the previously reported Rb-Sr age for this kimberlite and therefore supports the case for a contemporaneous emplacement for at least some Southern Indian kimberlites. They opine that it is far from conclusive until ages of more of the kimberlites in the area have been determined by employing similar techniques. The other two papers by this group is on kayanite-eclogites from the Kalyandurga cluster. Their study suggests low Os contents (29 – 100 ppt) in these xenoliths which are more akin to Siberian eclogites rather than the Os-rich South African eclogites. Re contents of the WKF eclogites are surprisingly low (9.6 to 92 ppt) and are at the lower end of any so far reported. This results in low Re/Os ratios. These authors discuss the possible cause for the very low Re content in the WKF eclogites.

Another line of research addressed the problem of nature of the transition zone between the two cratonic blocks of the Dharwar craton with the help of mantle xenocrysts study across the blocks. Griffin and his co-workers have studied the garnets and mantle derived xenocrysts from kimberlites along a traverse extending SW-NE across the E margin of the Closepet Granite. This study concludes: (1) at 100-200 km depth, the EDC-WDC suture lies near the eastern margin of the Closepet Granite, suggesting that the batholith is the crustal expression of a lithosphere-scale boundary; (2) The SCLM near the suture is strongly refertilised, perhaps during craton assembly; (3) The differences in the SCLM beneath the WDC and EDC suggest that each cratonic block carried its own "root" at the time of their collision; the root beneath the margin of the EDC may already have been less depleted, or it may have been refertilised by fluids moving along the suture.

A possible method of constraining the relative contributions of lithospheric and asthenospheric material to kimberlite magmas is to contrast intrusions emplaced in regions with differing cratonic roots. Chad Paton and his co-workers have utilized this approach to study the kimberlites of the Wajrakarur and Narayanpet kimberlite fields. Their study has suggested similarity in elemental and isotopic compositions in the kimberlites of above two fields implying the REE and HFSE were largely unaffected by assimilation of lithospheric material, and are a good reflection of the asthenospheric source component. These authors also draw the similarity of Nd and Hf isotopes in Indian kimberlites to Group I kimberlites in Greenland and southern Africa, despite a significant distribution in space and time, suggests that a common process within the asthenosphere may be responsible for kimberlite formation.

There were pre-conference and post-conference field trips to (i) kimberlites in Finland (7-9th August, 2008), (ii) volcanology of the West Eiffel Maars and its relevance to the understanding of kimberlite pipes (7-10 and 16th-18th August) (iii) Tertiary Rhine Graben volcanism: Kaiserstuhl and Hegau (8-10th August), (iv) The Ronda peridotites and lamporites in Spain (16-22 August) and (v) Lamproites and related rocks of Serbia, Makedonia and Turkey (16-24 August, 2008).

10th IKC – Bangalore, February 2012

On Wednesday afternoon, R.H. Sawkar, on behalf of Geological Society of India, diamond exploration industry, government organizations and academic institutions, made presentation before the International Kimberlite Conference Advisory Committee (IKCAC) meeting held at the Institute of Geoscience premises of the Goethe University and invited the IKC to have its next conference in India. During the presentation, Sawkar highlighted the need for holding the next conference in India where (i) there is a recorded history of more than 3000 years of diamond exploration, (ii) availability of a huge potential for kimberlite research and diamond exploration and (iii) almost ninety percent of world diamonds are cut and polished and therefore form a significant part of the 'diamond pipe-line'. The presentation also proposed to have a significant departure, perhaps for the first time in the IKC programmes, to involve diamond cutting and polishing industry within the ambit of the IKC meetings. The conference venue was proposed as Bangalore where the headquarters of the Geological Society is located. On Thursday afternoon, R.H. Mitchell, the Chairman of the IKC Advisory Committee announced that the 10th International Kimberlite Conference would be held at Bangalore during February, 2012. This announcement was received with jubilation among the Indian delegates, which represented a unified picture and made commitment to make the 10th IKC a success.

The arrangements made during the entire conference were excellent. The organizers, particularly Gerhard Brey and Heidi Hoffer deserve all praise for the commendable effort. The IKCAC should also be thanked for having chosen the venue. Gerhard Brey and Heidi Hofer rightly pointed out in their inaugural note 'despite the progress made, we will, however, also learn that there is still a lot to learn and that we must continue with future kimberlite conference in order to perpetuate our understanding'. In the same spirit, the Geological Society of India, that would be acting as umbrella organization for holding the next IKC, would hope the industry and academia would once again meet at Bangalore during February, 2012 to review the progress made in the science and exploration of kimberlites and diamonds and once again identify the gaps in the knowledge to relay it to the next conference.

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