

NEWS AND NOTES

Short Course on Fluid Inclusion Studies – M.S.Rao, N. Rajendran and K.S. Godhavari, Geological Society of India (*Email: gsocind@gmail.com*)

The Geological Society of India has been organizing from time to time Short Courses on selected topics of relevance to Indian researchers and professionals by inviting internationally well-known and recognized experts in the chosen field.

With this objective, a short course on *Fluid Inclusion Studies in Earth and Planetary Sciences* was organized during 20-24 April, 2015 at the Sampat Iyengar Hall of the Geological Survey of India (GSI) at Bengaluru. The course was presented by **Prof. Robert John Bodnar**, C.C.Garvin Professor of Geochemistry and University Distinguished Professor, Department of Geosciences, Virginia Tech., Blacksburg, VA, USA. Prof. Bodnar is not only a stalwart in the field with over four decades of sustained research output but also an outstanding and passionate teacher eager to share his rich experience in the subject matter with youngsters. He is a recipient of many awards including the Waldemar Lindgren Award (1986) of the Society of Economic Geologists, The N.L. Bowen Award (2005) of the American Geophysical Union and the N.P. Eramakov Prize (1998) of the Asian and Pacific International Fluid Inclusion Society. Mention may be also made of the beginnings of Prof. Bodnar's career as a co-worker of late Dr. E.W. Roedder (considered as the father of modern fluid inclusion research) in the United States Geological Survey (USGS), when the work on the first modern fluid inclusion study equipment, namely the USGS-type-Gas-Flow Heating and Freezing stage was in progress. This became the prototype of the subsequent developments in Fluid Inclusion instrumentation. Further, Prof. Bodnar imbibed from Roedder his enduring interest in fluid inclusions as samples of the ore-fluids and has made many significant contributions in elucidating the genesis of different genetic type of ore-deposits (including precious-metal deposits).

About 40 participants drawn from

various central and state governmental/public sector organizations, academia and mining industry participated in the course (Geological Survey of India, Atomic Minerals Directorate for Research and Exploration, National Geophysical Research Institute, Hyderabad; National Centre for Earth Science Studies, Trivandrum; Department of Mines and Geology, Bangalore; The Hutti Gold Mines Limited, Hutti; Rajasthan State Mines and Minerals Ltd., Udaipur; Indian Institute of Science, Bangalore; Indian School of Mines, Dhanbad; Osmania University, Hyderabad; Kuvempu University, Shivamogga; University of Kerala, Thiruvananthapuram).

The inaugural function of the course took place on the forenoon of 20 April, 2015 at the Sampat Hall of the Vasudha Bhavan, the GSI office-complex in Bangalore. Shri N. Devaraj, Deputy Director General and HOD, Remote Sensing and Aerial Surveys, GSI was the Chief Guest at the function. Prof. C. Srikantappa, UGC-Emeritus Professor from the Department of Studies in Earth Sciences, Mysore University and an avid researcher in Fluid Inclusion Studies in this part of the country, and Shri T. Krishnappa, Deputy Director General, State Unit: Karnataka and Goa were the Guests of Honour at the function. Shri Devaraj in his opening remarks appreciated the efforts of the Geological Society of India in organizing such a course presented by one of the leading researcher like Prof. Bodnar and hoped that the participants would take the fullest benefit from the course. Prof. Srikantappa narrated his own experiences in organizing the fluid inclusion study laboratories of the Mysore University and the new insights gained by fluid inclusion studies in metamorphic petrology in general and granulite-genesis in particular. He also emphasized the importance of fluid inclusion studies in elucidating the genesis of ore deposits. Shri Krishnappa expressed his gratification that a group of younger

geologists are getting exposed to the fundamentals of fluid inclusion research by a master in the field and urged the participants to fully utilize the presence of Prof. Bodnar by active interaction.

Professor Bodnar expressed his great pleasure in visiting India for the first time and the opportunity to interact with the younger generation of geoscientists from diverse organizations in India engaged in or interested in the application of fluid inclusion studies in their own work. The inaugural lecture by Prof. Bodnar on "Whole Earth Water Cycle", which was open to all, dealt with the wide gamut of Whole Earth Geohydrologic Cycle, from the clouds to the core of the earth bringing out an entirely new perspective about the overall distribution of water in different forms in the Earth as a whole. Distribution of water in the exosphere (atmosphere, biosphere, oceans, surface waters, groundwater, glaciers and polar-ice) and in geosphere (continental crust, mantle and core) and the linkages to plate tectonics was also touched upon. This lecture provided the appropriate backdrop for the course lectures on fluid inclusion studies, which were followed from 20 April afternoon to 24 April forenoon at the same venue. The topics dealt with by Prof. Bodnar in the course may be summarized as follows:

1. Introduction to Fluids. 2. Composition of Natural Fluids. 3. Fluid Tracers. 4. Introduction to Fluid Inclusions. 5. Phase Equilibrium Properties of Fluids. 6. Fluid Inclusions in Porphyry Copper Deposits. 7. Fluid inclusions in Epithermal Gold-Silver Deposits. 8. Fluid inclusions in Mississippi Valley type deposits. 9. Fluid inclusions in Volcanogenic Massive Sulphide (VMS) Deposits. 10. Introduction to Melt-Volatile systems. 11. Melt inclusions in magmatic-hydrothermal systems. 12. Fluid Inclusions in Orogenic Gold Deposits.

On the 23 April, 2015, the course participants visited the Centre for Earth



(a) Lighting of lamp. (b) Prof. Bodnar honoured in the traditional way. (c) Prof. Bodnar interacting with the participants. (d) In the fluid inclusion lab of GSI (NCEGR). (e) Shri S.V. Srikantia giving away certificates. (f) Field visit discussions at Kabbaladurga. (g) Trainees along with Prof. Bodnar.

Sciences in the Indian Institute of Science to familiarize themselves with the Melt-Inclusion Stage at their Fluid Inclusion Lab.

On 24th forenoon, the course participants spent sometime in the Petrological Laboratories of the GSI [now rechristened as the National Centre for Excellence. In Geoscience Research (NCEGS)] discussing some practical aspects of fluid inclusion microscopy including the preparation of high quality doubly polished wafers depending on the specific minerals in which such studies are to be undertaken.

The valedictory function was held on the afternoon of 24 April, 2015 again at the Sampat Hall of the GSI-Office Complex, with Shri S.V. Srikantia, Vice-President, Geological Society of India as the Chief Guest and Shri N. Devaraj, Dy. D.G., RSAS, GSI as Guest of Honour. Shri S.V. Srikantia, in his remarks before giving away the certificates to the participants, emphasized the importance of integrating the field and laboratory data properly to obtain a meaningful picture of the geological evolution of a particular terrain. Shri N. Devaraj expressed his happiness at the successful completion of the course as evidenced by the active participant response and feedback. From the participant perspective, two representatives viz., Shri G.S. Tiwari (GSI) and Smt. A. Latha (AMD) spoke of their gratefulness to Prof. Bodnar for his almost continuous 7-hour lecture schedule each day (with minor breaks) and his abiding desire to share his deep knowledge in the subject matter. They felt that to learn from such an illustrious and committed teacher was indeed a rare opportunity that all the course participants valued immensely and would cherish. Prof. Bodnar was then honoured by the Society as well as by the participants in the traditional fashion.

In his Valedictory Lecture (open lecture) Prof. Bodnar delved on the future prospects of Fluid Inclusion Studies and Research in the Indian subcontinent. He began his lecture by saying that it would be presumptuous on his part to undertake this task but based on the geological framework of the subcontinent he would like to underscore the following: (1) With some of the extensive and best exposures of the Archaean/Precambrian terrain on the earth localized in the Indian shield, the role of fluids in the genesis of granulites and other high-grade rocks continues to be a fertile field of research in the cratonic blocks of the peninsular India and the enveloping mobile belts. (2) The thermal history of the evolution of the Himalaya with special reference to the ultra-high-pressure (UHP) eclogite facies rocks exhumed from the mantle depths is another area, where fluid inclusion research can shed some additional light. Prof. Bodnar also mentioned in this context the utility of decrystallization and reequilibration studies in elucidating the P-T-paths in metamorphic environments. (3) Melt inclusion studies in Deccan Traps, which constitute another major element in the crustal architecture of the Indian Geology, are of importance from the view point of magma genesis in large igneous provinces. (4) Kimberlites and associated rocks offered another important area for melt- and fluid-inclusion studies of far reaching significance. (5) Last but not the least, Prof. Bodnar emphasized the importance of fluid inclusion studies in ore-deposit research and exploration. He cited the example provided by characteristic secondary fluid inclusion assemblage trails in shear zones associated with gold- and precious-metal mineralisation as an aid in exploration activity in adjoining terrains. In his concluding observations Prof. Bodnar expressed his happiness and satisfaction at

the participant response and keenness to learn, by all those who attended the course, which makes any teacher's effort worthwhile.

M.S.Rao, who proposed the vote of thanks, expressed the indebtedness of the Geological Society of India to Prof. Bodnar for his ready acceptance of the invitation of the Society to present this short course at Bangalore despite his extremely busy academic and research schedules. He hoped that this first visit would pave the way for more such visits and a fruitful collaboration of some of the young workers from India drawn from different organizations with the Fluids Lab., of the Department of Geosciences at Virginia Tech. Blacksburg, VA, USA, after a good beginning made by this short course.

Prof. Bodnar visited the Department of Studies in Earth Science of the Mysore University on 25 April, 2015. Prof. Bodnar addressed the students of the Department on the topic of fluid inclusion studies in ore-genesis and in mineral exploration, which was followed by a lively discussion with the students and faculty. On 26 April, Prof. C. Srikantappa and a team of officers from GSI accompanied Prof. Bodnar on a field trip to the well-known Kabbaldurga quarry to see the incipient charnockitization process. On 27 April, Prof. Bodnar visited the Raman Research Institute to go around the museum and the personal mineral collections of Dr. C.V. Raman. Laser Raman Spectroscopy has currently become an important tool in fluid inclusion research. The last item in the programme on the same day before Prof. Bodnar left India, was to examine the typical exposures of the Peninsular Gneiss in the Lalbagh quarry (National Geological Monument) in Bangalore, as culmination of his very fruitful trip to India to offer this short course on Fluid Inclusion Studies.