1.3. APPLIED RESEARCH

A series of multielement NAA studies of ecological samples from the Kola peninsula to investigate technogenic transformation of podzolic *Al-Fe*-soil as a result of air pollution by copper-nickel production were completed. These studies were conducted in cooperation with the Institute of Industrial Ecology of the North of the Kola Scientific Center from 1992.

The first stage of the International Program for the study of atmospheric deposition of heavy metals on the territory of Romania was completed. Moss-biomonitors were collected in the Eastern Carpathians in 1995. The obtained results are represented as maps made using the GIS (geographic information systems) technologies (GIS-INTEGRO) in collaboration with the Department of Mathematics of the International University of Nature, Society and Man in Dubna.

Work to analyze peat samples from peat cores in Arctic Norway was fulfilled. A comparison was conducted of the results of the paleoclimatic reconstruction of the atmospheric deposition in the North with the new data obtained by the sector for neutron activation analysis and radiation research (NAA&RR) for peat cores from Switzerland and Indonesia in the framework of the collaboration with the Institute of Geology of the University in Bern, Switzerland.

One of the important directions of investigations in ecology by the NAA&RR sector is the study of the multielement composition of different fractions of atmospheric aerosols (AA) from West and East Siberia. This work carried out for a number of years in collaboration with specialists in atmospheric ecology from the Institute of Chemical Kinetics and Combustion of the Siberian Branch of the Russian Academy of Sciences (Novosibirsk) was successfully continued in 1997. Several hundreds of AA samples from different areas of the Novosibirsk, Krasnoyarsk, Tumen, Irkutsk, and Baikal regions have been analyzed using NAA. In some of them (the Tumen, Irkutsk and Baikal regions), a high content of a number of technogenic, including toxic elements – *Ni, Co, As, Cd, Mo, Ag, W,* is observed in AA. This is an alarming signal and is of interest for ecologists.

The data obtained for a large number of elements (45-65) were submitted to ecologists of the Institute of Chemical Kinetics and Combustion of the Siberian Branch of RAS and at present, are used to reveal the most significant sources and factors of technogenic pollution of the atmosphere over these Siberian regions as well as to study regional and local peculiarities and yearly and seasonal dynamics of changes in the AA element composition. A large amount of reliable data on the AA element composition obtained by NAA, one of the most sensitive and suitable techniques, is of importance for the formation of the data bank on the AA element composition (the work is carried out in the Siberian Branch of RAS). Several papers covering the results of the multielement NAA of atmospheric aerosols are to be published.

An analysis of moss-biomonitors collected near the Baikal paper producing plant in the summer of 1996 was performed. The results of this investigation presented at the International Forum "Safe Development of the Region" (July 2-6, 1997, Irkutsk) won the Second Prize of the Forum Organizing Committee.

The work initiated by the Department of Geography of Moscow State University and aimed at studying the microelement composition of ferro-manganese nodeles from one of the regions in the Pacific Ocean was completed.

Analytical studies of the NAA&RR sector to analyze rocks, soil, sediments and water contributed to the development of the experimental interrepublican system of ecological monitoring of the Terek basin.

The paper devoted to studies of the halogen distribution from the coast of the Arctic Ocean deep into the continent carried out in collaboration with the Norwegian University of Science and Technology (Trondheim), is prepared for publication.

At the NATO Conference "Ecological Problems of Industrial Regions of the Urals" held on May 25-30, 1997, three reports on the use of the biomonitoring technique to study atmospheric deposition of heavy metals were presented. This gained the appraisal of specialists from the Academy of Metallurgy in Magnitogorsk and the Institute of Biophysics in the town of Ozersk of the Chelyabinsk region (MAYAK Industrial Enterprise) and led to the development of a project for studying atmospheric deposition of heavy metals and radionuclides in the Chelyabinsk region by nuclear physics methods. The proposal for the project was submitted to the IAEA and has successfully developed into a co-ordinated research program on biomonitoring air pollution through trace element analysis.

Part of industrial monitoring work under the auspices of the other IAEA grant connected with monitoring of the plant for production of phosphorous fertilizers in the town of Voskresensk in the Moscow Region was completed and the the results were submitted to the IAEA as a yearly report.

In the framework of a special course "Neutron activation analysis as a nuclear physics method for the determination of the element composition of matter, its application to ecological studies" by M.V.Frontasyeva, four-year students of the Department of Ecology of "Dubna" University do practicals in the NAA&RR sector.

In 1997, investigations of semiconducting crystals of the A^3B^6-$A^3B^3C^6_2$ type with a highly anisotropic crystalline lattice structure continued. The electric and photoelectric properties of the heterojunction (HJ) in a *TlSe* - $TlInSe_2$ system obtained by the liquid-phase epitaxy method from a *TlSe* melt on the surface (110) of $TlInSe_2$ are described in the framework of the model of an isotypical HJ without local states on the interface. The main parameters of HJ – the boundaries of free and valence zones, equal to E_c=0.69 eV and E_v=0.05 eV, respectively, were estimated. The peculiarities observed in the HJ photoresponse spectra were explained using the Dember effect. The results are to be published in "Physics and Technology of Semiconductors" and "Nuclear Instruments and Methods".

Studies of defect structures in crystals with specific physical properties which are of interest for applied research, continued.

Defect formation in nonstoichiometric crystals in solid zirconium oxide and yttrium oxide solutions with different concentrations (the monocrystals were grown by E.E.Lomonova and V.V.Osiko) was investigted using two diffraction methods: (1) diffusion scattering to determine short-range order and (2) Bragg diffraction to determine the middle structure. The experiments were carried out with participation of Bente Lebech in the Riso National Laboratory, Denmark, and Arthur Schulz in the Argonne National Laboratory, USA. It is shown that in the cubic structure the main peculiarities of the diffuse scattering pattern are connected with the existence of implanted oxygen atoms and the fact that the population of their positions changes little as the concentration of yttrium oxide changes. At the same time, an increase in Laue diffuse scattering as the concentration of yttrium oxide increases is probably connected with an increase in statistical

isotropic displacements in the *Zr/Y* averaged position. It is established that in the tetragonal phase, the observed strong hardening of crystals is connected with the coexistence of coherently linked cubic and tetragonal phases with a low yttrium oxide concentration. Most recent results are obtained with the high resolution Fourier diffractometer in FLNP.

The cycle of neutron diffraction measurements to investigate the defect structure of a *C60* fullerene crystal (grown by R.K.Nikolaev in ISSP in Chernogolovka) was conducted by the same group of people in Riso and ANL at room temperature, 200 K and 20 K.

The data processing and a symmetry analysis of the reciprocal space geometry of fullerenes are under way. As a preliminary result, it is established that several twinning systems exist in the fullerene crystal and its symmetry in the low temperature phase is not P a-3, as it is accepted in the literature, and is sooner lower than that.

The main tasks of the NAA&RR sector for 1998. In accordance with traditional research themes the main objectives of the sector in 1998 are the investigations in the field of ecology and environmental protection. In the framework of the European Program "Atmospheric Heavy Metal Deposition in Northern Europe 1995" monitoring of several regions in the Arctic, Norway, Finland, and Rome as well as studies of the multielement composition of atmospheric aerosols in West and East Siberia (the "Aerosols of Siberia" and "Aerosols of Baikal" projects) will be continued. Several research projects and programs are under preparation in collaboration with the Institute of Limnology of SB RAS (Study of atmospheric aerosols and sediments of Lake Baikal); Swiss Institute of Geology (Study of element composition of peat cores from different regions of the world for paleoclimatic reconstruction); Institute of Radioecological Problems, Minsk (Study of the effect of the Chernobyl accident on the health of children); Institute of Geology, RAS and V.I.Vernadsky Institute of Geology and Chemistry (Estimation and prediction of a balance in the distribution of toxic elements in technologic flows from the Astrakhan gas-refining complex), a number of the Urals Institutes and the IAEA (biomonitoring of atmospheric deposition in the Urals regions with a high technogenic impact).

In the field of condensed matter physics, the mechanisms of electric conductivity in heterojunctions (volt-ampere and volt-capacitive characteristics) in crystals with a highly anisotropic crystalline structure will be investigated. For this purpose, a *p-p-TlSe-TlInSe$_2$* heterojunction will be produced for which the material for epitaxial *TlSe* plating will be preliminarily purified by the zone recrystallization method up to the concentration of acceptors $N_{a1} \sim 10^{15}$-10^{16} cm^{-3}, and the substrate material *TlInSe$_2$* will be alloyed with *Se* up to the concentration of acceptors $N_{a2} \sim 10^{14}$-10^{15} cm^{-3}. This will make it possible to improve the HJ detector characteristics, i.e., increase the current sensitivity to g-n radiation, extend the range of spectral sensitivity to include the long-wave region, decrease the response time, etc.