Analysis of the Version "Earthquake is the Cause of the Chernobyl Accident"

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For the first time an earthquake as a possible cause of the accident at the 4th unit of Chernobyl NPP was discussed in 1996, after publication of an article by Vitali Pravdivtsev "Chernobyl: 10 years after" in December issue of "*Technika – molodezhi"* magazine. It was argued in the article that the reactor was destroyed by an explosion after the earthquake which occurred under the nuclear power plant at 01:39 AM 26 April 1986. The article attracted attention of nuclear physicists at Kurchatov Institute of Atomic Energy (KIAE), and with assistance of geophysicists they promptly checked the information provided in the article. A clear mismatching of the time of the described event and the moment of the beginning of breakdown process at the NPP forced them to systematically reveal and count all mistakes and discrepancies of Vitali Pravdivtsev's article (there were more than 80 of them). That's why the result of comparison of the drawing from the article (by which the author supported his sensational conclusions) with the original of seismograms, presented by geophysicists participating in the investigation, was not surprising. They stated that "an illustration (that was the word they used for Pravdivtsev's seismogram – *N.K.)...* is a hand-made drawing of the imaginary event that allegedly occurred at 1:39! [1]". Pravdivtsev, the author of the article, did not dare to argue with experts' conclusions.

In 1997 a group of scientists from the United Institute of the Physics of Earth (RAS, Moscow, Russia) Institute of Geophysics of NAS of Ukraine, Institute of Geography of NAS of Ukraine revisited this theme. Although their conclusions were formulated in a more prudent manner, they preserved a less-stringent approach to the selection of facts that they needed to prove their point. For example, it is stated in the paper that the seismic event occurred (with one second precision!) at 01:23 39±1 s. At the same time, an inaccuracy of the distance to the epicenter of the seismic event is ± 10 km, which immediately adds to the error of the moment of seismic event ± 3.4 s (10 km divided by velocity of surface waves V=2.9 km/s gives 3.4 s). Besides, the paper did not indicate the moment of receiving seismic signal at registration points, i.e. at seismic stations, and distance which the signal traveled from the point of origin – all this makes verification of authors' conclusions difficult.

A little later (in 2000) the same group of authors wrote on Chernobyl accident again [3]: *"Weak earthquake (MPY = 2.6, MS = 1.4) was recorded by three seismic stations in the area of Chernobyl NPP... Preliminary analysis of the seismograms tells of the natural origin of the shake..."*
An accuracy of the distance to epicenter was specified by the authors once as ± 10 km [2], then as ± 15 km [3]. Although this fact leads to the increase in uncertainty of the moment of event to (1± 5.3) s, it is not taken into account.

Further on in the papers an appearance of a "low frequency extensional clatter and strong vibration of units" is described, with indication of the precise time (allegedly documented by the NPP personnel) when this event started. This is not true. Yes, there was vibration and clatter during 6-8 seconds, as witnesses stated. But there was no registration of these events as commencing at precisely 1:23:39 (there is no proof for this in these papers). Even with one-minute precision no one at Chernobyl NPP noticed the commencement of "clatter and vibrations", because explosions that followed brought totally new tasks (evidences provided by witnesses give time between 1:15 to 1:25, and records of personnel which participated in the programme – 1:24-1:25).

One more point. Authors consider only two hypotheses on the nature of the event which was registered by seismic stations: earthquake and explosion. Thus they have overlooked a third version, namely that seismic stations might have recorded, for example, the following sequence of events:

- most powerful clatter and hydroblows which accompanied local increase of power generation in the lower part of right half of the reactor; during this period control systems recorded drop of flow rate through all eight main circulation pumps [5];
- several explosions – one of them lasting, resembling a double explosion, and in 2-3 s a very strong third explosion (quotation from explanations by personnel).

Thus, even from preliminary analysis of papers [2, 3] it is possible to conclude that authors were willing to relate the accident at unit 4 of Chernobyl NPP with a hypothetical earthquake.

Let's quote from the abovementioned papers some excerpts, which served as a basis for authors' conclusions:

"An analysis conducted at KSE OIEPh RAS shows that in the night of 25-26 April 1986 (25 April at 21:23' Greenwich time) all three stations recorded a relatively weak seismic event. Surface waves could be seen on all channels of three stations...

For estimates of the time of event and coordinates of epicenter of seismic source... velocity of surface waves with the period about one second was used (2.9 km/s)...

Results of the analysis of seismic records show that the examined event took place at 01:23:39 (± 1s) local time (here and further on local time is used for chronology of the events at Chernobyl NPP)...

The time of the seismic event recorded by the KSE OIEPh RAS stations coincide with the accuracy to first seconds with the low frequency extensional clatter from the direction of water intake station at the cooling pond and strong vibration of units (01: 23: 38)...

In accordance with estimates which could be found in different reports, the explosion at unit 4 of Chernobyl NPP occurred during the time interval from 01: 23: 49: to 01: 23:59. Thus it is possible to assume that the event in question did occur at least 10 s before the explosion at ChNPP, but more likely 16 s before...

It was estimated that the epicenter lay about 10 km to the East of ChNPP. Low amplitudes at seismograms and the fact that stations were located at one side from epicenter would not allow for better accuracy of epicenter location than ±10 km. Thus it could not be ruled out that the epicenter of the event may coincide with the location of the NPP.

It is not possible with the available data to make estimates of the depth of the source...

Dynamic characteristics of the seismograms differ from recordings of the surface explosions and resemble forms of the registered local earthquakes which were obtained during seismic monitoring of Chernobyl NPP in 1995-1996...

Direct comparison of the form of the Chernobyl event record and records of explosions at local quarries at similar distances was also made.

Finding out the tectonic nature of the seismic event is based on data of detailed seismic description of the territory of Chernobyl NPP... Additional investigation provided evidence that... the highest number of micro-earthquakes is observed... at a distance 10-15 km to the East of ChNPP... Thus, the most likely center of the local earthquake of the night of 25-26 April could be the junction of Teterev and South-Pripiat deep faults, located 10-15 km to the East of ChNPP site...

Envelope line of maximum seismic intensity... may lead to the estimate of earthquake intensity of 7.25. These estimates, of course, are made for epicenter of the earthquake.

Note that due to resonance effects in buildings accelerations could be several times higher. Hence it could not be ruled out that the system of reactor, unprotected against vibrations, would suffer from seismic impact during testing, and this would lead to disruption of technological processes and eventually to an explosion of the reactor.
Evaluated... intensity of seismic shakes at ChNPP industrial site in these cases would be equal approximately 2...
In case of epicenter location at the depth up to 1 km, from formula... we obtain the magnitude 5-6...
Conclusions. *So, the obtained data indicate that the considered seismic event with... epicenter near ChNPP occurred, most likely, 16 s before the explosion at the power plant; its beginning approximately match the time of low-frequency sound and vibrational effects, noticed by power plant operators; spectral- time characteristics of this event significantly differ from records of the quarry explosions with epicenters at the same distances.*
Hence it is possible to conclude that there is a high likelihood that the system of reactor 4 of Chernobyl NPP, unprotected against vibrations, suffered from a seismic impact combined with resonance effects, and that made insertion of the graphite absorption rods impossible, a sharp increase of reaction was not prevented and this resulted in intensive generation of gases and their explosion."

Let's consider two hypotheses on the nature of the recorded event. According to the first one, the recorded signals are a consequence of one or two explosions at the ChNPP, which occurred due to an accident at unit 4. According to the second hypothesis, an earthquake occurred in the area of ChNPP. Let's look how the real fact can match these hypotheses.

Comparison of the events at ChNPP 26 April 1986, which was presented in official materials of the Governmental Commission of the USSR on the investigation of the causes of the accident at ChNPP, including the well-known report, prepared by USSR for IAEA experts [Abagian et al., 1986], as well as in reports by Institute of Nuclear Researches of Academy of Science of Ukrainian SSR, *NIKIET* and reports by the Complex expedition of the Institute of Nuclear Energy (INE), demonstrates the following:

- The moment of the beginning of the seismic event, registered by seismic stations, within seconds coincides with the low-frequency clatter from the side of water-intake station at the cooling pond and strong vibration of units, noticed by power plant operators (1:23:38).
- At 01:23'40" the unit shift supervisor ordered pressing button EPS-5, which commands insertion of absorption rods in the core. The rods moved downward, but in several seconds shocks were heard and operator saw that the rods stopped before they reached lower limit stop switches.
- At 01:23:48 technological control devices recorded grows of pressure in the reactor and in steam separator drums.
- Not later then 01:23:49 the centralized monitoring system "*SKALA*" switched itself off.

According to estimates made in different reports, the first explosion at unit 4 of ChNPP occurred during interval from 1:23:49 to 1:23:59. If one uses only records of the NPP personnel and readings of the NPP control system, then some impact on the NPP did take place between 21 and 11 sec before the explosion. Results of the analysis of seismograms show that seismic source also appeared 11 seconds before the control system failed to function. According to the record in operating log, at 01:39 one more explosion occurred, but for some reason it was not recorded by the seismic stations.

On the basis of these facts reports conclude: "*It is not possible to rule out the possibility, that the system of reactor 4 of Chernobyl NPP, while it was operating in upset conditions, suffered a seismic impact and this led to impossibility of insertion of graphite absorbing rods with all implied consequences*".

Is this conclusion trustworthy? To answer this question, let's consider in more detail information presented in papers [2, 3]. If the facts are presented in a table, we will have a compact and easy to analysis form of the material.

Table 1. Data from papers on seismic event near ChNPP (26.04.86).

1. Seismic event occurred at 1:23:38±1
2. Moment of registration of event at the sites of seismic stations – NOT CITED
2. The depth of the source of seismic event - NOT DEFINED.
3. Distance from seismic stations to epicenter of the event - NOT CITED
4. Accuracy of distance to epicenter - ±10 km, ±15 km
5. Most likely location of epicenter - 10-15 km to the East of ChNPP.
6. Intensity of seismic shakes on industrial site of ChNPP – 2.
7. Oscillation which was registered best – SURFACE WAVES.
8. Velocity of propagation of surface waves - 2.9 km/s
9. Explosion at unit 4 occurred during interval from 1:23:49 to 1:23:59.

Table 2 Conclusions of the papers on seismic event in the area of ChNPP (26.04.86).

1. «Some impact on NPP did occur during the period 21-11 s before the explosion».
2. «Seismic stations recorded not explosion or several explosions, but an EARTHQUAKE».
3. «So, the obtained data indicate that the considered seismic event with... epicenter near ChNPP occurred... 16 s before the first explosion at the power plant»
4. «Envelope line of maximum seismic intensity... may lead to the estimate of earthquake intensity of 7.25. These estimates, of course, are made for epicenter of the earthquake".
5. «Hence it is possible to conclude that there is a high likelihood that during the period of testing the system of reactor 4 of Chernobyl NPP, unprotected against vibrations, suffered from a seismic impact and that, combined with resonance effects, made impossible an insertion of the graphite(?) absorption rods to stop reaction runaway, and this resulted in intensive generation of gases and their explosion.»
6. «According to the record in operating log, at 01:39 one more explosion occurred, which was not recorded by the seismic stations.».

Comparing the information in Table 1 and Table 2, one can notice obvious mismatch between the initial data and conclusions made on the basis of these data.

Let's consider this phenomenon in more detail. **To begin with, lets try and find an answer to the question – are earthquakes of 6 points and more possible in the area of ChNPP?**

The following is the answer to this question provided by the Research and Design Institute of Building Elements of the State Committee of Civil Engineering of the USSR (*НИИ строительных конструкций Госстроя СССР*) in 1995 [4]: *«Analyzing the map of general seismic zone classification OCP-87, presented by the Institute of Earth Physics of the Academy of Science of USSR, as well as information on earthquakes of 1230 and 1510 on the territory of Kyiv oblast... the area of the ChNPP is indeed located on the border of 5 and 6 point seismic zones...*

An earthquake of 1230, according to the data of S.V.Evseev..., for Kiev region also could be ranged as 6-point (S.V.Evseev writes "6-?") according to the description in Lavrentijevsky Chronicle... a collapse of the stone church (if it was not decrepit or poorly built, and the data were not exaggerated) corresponds, in *accordance with the scale of intensity of earthquakes MSK-84 to the intensity about 7 points (more than 6). However, this single fact (even if it indeed occurred) is not sufficient for ranging this zone as 7-point, because subsequent (well documented remote earthquakes of the Vranch zone (ZONA VRANCHA) earthquakes of 1790, 1802, 1940, 1977… according N.V.Shebalin's data did not exceed 5 points on MSK-84 scale for Kiev and its vicinities».*

One more question – what was the assumed seismic impact which main buildings of the ChNPP had to withstand? This is an answer provided in 1995 by the institute "Atomenergoproekt" (the question, and hence the answer, were relevant for both 3rd and 4th units of ChNPP [5]: *«The "Norms of designing nuclear power plants with reactors of different types" (PiNAE-5.6), enacted in 1.01.87, require that buildings and constructions of NPP of the 1st category in terms of their radiation and nuclear safety, should be designed taking into account particular impacts, including seismic impacts: Design impact (DI) and Maximum design impact (MDI). The former and the letter are defined for Chernobyl NPP as follows: DI – 5 points, MDI – 6 points.*

…In accordance with categorization of PiNAE-5.6, constructions of the main building: main compartment (units A, B and BCPO) and deaerator construction were assigned 1st category.

Taking this into account, the Moscow Branch of "Atomenergoproekt" Institute in 1987 accomplished theoretical and experimental investigations of earthquake resistance of constructions (equipment) of buildings belonging to categories I and II for Kursk, Smolensk and Chernobyl NPPs.

Results of these investigations are presented in the report "Measures to provide for seismic resistance of nuclear power plants with reactors RBMK"...

Calculations that were carried out demonstrated that load bearing capacity of constructions of main compartment (units A, B and BCPO) and deaerator construction, with seismic impacts taken into account, are in general achieved».

Next question: did the personnel of ChNPP identify the shaking it experienced as an earthquake?
Personnel of shift N 5, which worked at ChNPP in the night of 26.04.86, did not hear the clatter of earthquake. Even the explosion, which demolished the unit 4, was not heard by all, nor in all rooms of the station. From almost 20 explanatory notes (which the author of this paper has at hand), which were written by the duty personnel of 26.04.86, it follows:

- personnel of the station, which was outside of the main building (*ABK*-2), noticed at first activation of the main emergency valves (*GPK*), then "awful noise" or clatter with rattle, strong vibration of the building and hollow roar, after which a shower of glowing (burning) debris of various forms and sizes;
- people who were in the main building noticed prolonged and intense low-frequency sound similar to hydro-shocks, which could be heard only in the premises adjacent to mechanical and reactor equipment (at Control Room of unit 4, in turbine building, in the premises of main circulation pumps and the like); not everybody heard these sounds – some noticed only "shaking" or "trembling" of the floor and walls (in the premises of *KRU*, "*Skala*" etc.);
- for controllers of the central Control Room of Unit 3 (adjoining Unit 4) everything began with the most powerful shocks and sounds of explosions, and then a dust fog appeared in the Control Room and sharply increased readings of radioactive background gauges;
- simultaneously with shocks, in corridors and premises of the main building of NPP (located at 9 m and higher) almost instantly a lot of dust appeared (it was compared with white fog), maybe through cable ducts, as one of the eye-witnesses commented;

- in some premises people experienced penetration of an air wave, even where doors were closed; then followed two combined blows perceived as one prolonged explosion, after which followed a third powerful blow (explosion) from some upper point (upper explosion);
- from the moment when intensive vibrations (blows) appeared, until the first explosion which was perceived by witnesses as a double prolonged explosion in the area of the core and main circulation pump (lower explosion), a time period estimated by witnesses was (an average) from 6 to 8 seconds;
- estimate of the interval between the double blow and the third – from 1 to 3 seconds;
- duration of the whole process, according to their impressions – from 7 to 11 seconds;
- those who were near the reactor premises of unit 4 noticed blows of extraordinary power, it seemed to them that monolithic concrete wall may collapse any moment.

And, at last – when did these events happen?
It is possible to arrange them (using texts of explanatory notes of the ChNPP personnel) in the following order:
1) vibration of buildings and equipment;
2) activation of emergency valves (*GPK*);
3) first and second explosions, as one prolonged explosion;
4) shaking of buildings and constructions caused by first explosions;
5) the last explosion.

It should be noticed that people who were in the lower level premises of the main building did not hear the sound of activated *GPK*. People who were in the nearby buildings not far from reactor section mentioned in their explanatory notes appreciable "shaking" simultaneously with the sound of out-through of steam through *GPK*.

Let's consider in more detail the sequence of events which was reconstructed above in accordance with evidences of witnesses.

Point 1.
At 01:20:30, growth of reactor power began (reading of the device of physical control of reactor energy release – *SFKRE*). Insignificant (within the range of regulation by the rods of automatic regulator AR) increase of reactor power was compensated by the AR-1 system, until it was fully inserted in the reactor, then an automatic power regulator AR-2 started working. By 01:23:39 the reactor power increased by 30 MW. This was initiated by the positive steam effect due to reduced water flow in the circulation loop after 01:23:04, when four MCP started working from "rundown" of TG-8. From 01:23:04 to 01:23:39 water flow decreased [6] by 5,800 m^3/h (from 56,800 to 51,000 m^3/h). In the beginning the process was gentle, decrease of flow was on the level of 180 m^3/s.

At 01:23:39 (reading from teletype; from DREG reading at 01:23:40) EPS-5 signal recorded (as A.S.Diatlov, the supervisor of testing, stated, as well as it follows from explanatory notes of Metlenko G.P. and Kukhar - chief of shift ordered that senior reactor engineer should press the EPS-5 button). The EPS rods started to move down into the core, introducing negative reactivity during the first second and then positive reactivity during 2 second (thus a deficiency of EPS rods manifested itself – the so called "effect of displacements"). Reactivity from increased steam concentration in the core was added to this, since the flow rate through MCP decreased three time faster after switching off of rundown MCP 14, 24,13, 23 from bus lines of sections 8 *RA* and 8 *RB*. This happened during interval 1:23:41.3 to 1:23:41.9, most likely due to activation of MCP emergency protection when water flow rate dropped to 5000 m^3/h. There was no activation of protection due to minimal voltage on electric motors (0.75 Un, with delay of activation 0.5-1.5 s, as indicated in [7]), because voltage on sections 8 *RA* and 8 *RB* (recorded on oscillogram) was no lower than 84% of nominal value. Approximately 3 s after disconnecting of rundown MCPs from the grid, reverse valves between MCPs and pressure pipeline started closing.

At 01:23:42 (recorded by *DREG* at 1:23:43) – appear emergency signals of reactor overpower and of exceeding power increase rate (*DREG* cycle N 135*D*).
So, not later than at 01:23:42 local power runaway commenced in the reactor with a doubling period of about 1 s, which could not be accompanied by clutter, roar and vibration of engineering structures.

At 01:23:45 – not later, shutting down of reverse valves on rundown MCPs.
At 01:23:46 (*DREG* – 1:23:47) flow rate dropped to zero through rundown MCPs and at least by 35-40 % in other MCPs [6]. This could be done only by a huge force applied from reactor. With that, impulse for closing was received by the reverse valves *Du* 300, installed on all 44 *RGK*. Besides, from 01:23:45 on the buses of 8*RB* section changes of currents began with variation 217-320 A and frequency 3 to 10 per second. They lasted about 3 s and finished when the current increased to 2170 A during the last second before the section was fully switched off at 01:23:49.
From 01:23:46 a current instability on buses of section 8 *RNA* was noticed, with a peak (looking like short circuit) at 01:23:47. Analysis of oscillograms shows that from 01:23:46 sections 8 *RB* and 8 *RNA* reflected events which happened with the pumps powered through these sections, including short circuits and failures.
It should be also noticed that during all period connected to section 8 *RNA* (after initial stages when start-up currents are much higher) that current through the section was higher by 500-550 A than the sum of nominal currents of the equipment connected to this section.

Point 2.
Activation of *GPK* (emergency valves) begins at the pressure 75 kg/cm^2 in *BS* (separator drums). Between 01:23:45 and 01:23:46 pressure in *BS* on the right side exceeded predefined level for activation of *GPK* and all 8 *GPK* were activated.
In this same cycle (N137D) *DREG* recorded activation of *BRU-K1* and sharp decrease of flow rate in *KMPC* cooling contour to 18,000 m^3/h (flow through running down MCP fell to 0). These events – cannonade from activation of *GPK*, shutting of reverse valves on MCPs, *RGKs* and from hydroshocks accompanying this process completed the phase which preceded destruction of the reactor core.

Point 3.

At 01:23:49 (in N 138 D cycle) a signal K06L005=1 was recorded. This signal spells that the pressure in the reactor space exceeds 0.15 kg/cm^2 (due to rupture of one or several fuel channels). Time period during which the prescribed level is reached is at least 1.4 s [6-8], and this causes delay of the emergency signal by the same time period. That's why the ruptures of the fuel channels should be timed at **01:23:47.**
Increased pressure in the reactor space tears lower and upper compensators of system *OR* (lower core plate structure) and system *E* (upper core plate structure). Premises of *SLA* (steam localization space), *BS* (steam separation drum) and *CZ* (central hall) get connected with the reactor space through under-reactor space and safety valves. For some time this reduces growth of pressure in reactor space.

It is quite likely that these events were perceived by witnesses as the first (lower) double explosion.

<u>Point 4.</u>
Explanations of witnesses show that the last (upper) explosion was heard 1-3 s later than "lower", i.e. approximately at 1:23:49-1:23:52. And switching off of reliable power supply, caused by the explosion, occurred at 1:23:49.
Thus it is possible to assume that the emergency process, which was accompanied by vibration, hydro-shocks and explosions began not later than 01:23:43 (beginning of power runaway) and ended not earlier than 01:23:49 (upper explosion).

Conclusions
If the calculated time of the beginning of the seismic event (at a distance 10-15 km from ChNPP) was correctly pointed out by the authors of "earthquake" papers (01:23:39), then taking into account uncertainty of the distance to epicenter, it will fall within interval 01:23:39±6 s. If we superimpose (moving closer to seismic stations) the calculated point of epicenter with coordinates ChNPP, the time when the event occurred will be 01:23:45. In this case the seismic event began immediately after the beginning of the wrecking phase of the emergency process in the reactor, which was at 01:23:43 as demonstrated above. **That's why we can state that on 26.04.86 seismic stations recorded local and powerful shakes (blows, explosions), which accompanied disastrous destruction of Chernobyl NPP unit 4.**

References

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Annex 1

Fragments from *DREG* data tape [7]

№ цикла Время Интервал Gгцн11 Gгцн12 Gгцн13 Gгцн14 Gгцн2I Gгцн22 Gгцн23 Gгцн24
ДРЕГ события цикла расходы теплоносителя через ГЦН

118Д 1.23.04 (04) *K07L053=1 СТОПОРНЫЕ КЛАПАНЫ ЗАКРЫТЫ
118А 1.23.06 7.25 7.15 7.47 7.17 7.35 5.67 7.30 7.45
119А 1.23.08 7.22 6.47 7.72 6.67 7.25 6.52 6.95 6.55

122Д 1.23.11 (10-11)*K07L202=0 СНЯТИЕ СИГНАЛА ПО НЕИСПРАВНОСТИ АР

127А 1.23.22 7.15 6.60 6.72 6.55 7.17 6.42 6.25 6.25
128Д 1.23.23 (22-23)*KIOL064=0 СНИЖ. ДАВЛ. ВОДЫ ВПРЫС. В КНД I

132А 1.23.36 6.92 6.72 6.42 ***5.45*** 7.25 6.12 6.02 6,12
133А 1.23.39 6.92 6.60 6.05 5.62 7.37 6.45 5.67 ***5.50***
134Д 1.23.40 (39) *K06LQI5=1 **АЗ-5 СУЗ**
134Д 1.23.40 (39) *K06L042=1 СТЕРЖНИ СОШЛИ С ВК
134Д 1.23.40 (39) *K06L040=0 НЕИСПРАВНОСТЬ ИЗМЕРИТЕЛ. ЧАСТИ 2АР
134Д 1.23.40 (39) *K06L151=1 РЕГУЛЯТОР П2-1332 ПОДКЛЮЧЕН ПРИ АЗ
134Д 1.23.40 (39) *K06L146=1 РЕГУЛЯТОР П1-1332 ПОДКЛЮЧЕН ПРИ АЗ
134Д 1.23.40 (39) *K06L143=1 РЕГУЛЯТОР П2-1332 В РЕЖИМЕ АВТ.
134Д 1.23.40 (39) *K07L202=1 ОТКЛЮЧЕНИЕ АР ПО НЕИСПРАВНОСТИ

134Д 1.23.40 (39) *KIOL045=1 РАЗГРУЗКА ТГ ПРИ АЗ-5
134А 1.23.43 7.05 7.35 5.65 5.75 7.72 6.42 ***5.50*** 5.80
135Д 1.23.43 (39-43)*K06LOI7=1 АЗСР (СНИЖ. ПЕРИОДА В ОСНОВН. ДИАПАЗОНЕ)
135Д 1.23.43 (39-43)*K06LOI6=1 АЗМ (ПРЕВ. МОЩН. В ОСНОВН. ДИАПАЗОНЕ)
135Д 1.23.43 (39-43)*K06L053=1 ПРЕВЫШЕНИЕ N АВАРИЙНЫЙ В 2УЗМ-1
135Д 1.23.43 (39-43)*K06L052=1 ПРЕВЫШЕНИЕ N АВАРИЙНЫЙ В 2УЗМ-2

135А 1.23.45 7.65 6.62 5.97 ***5.20*** 7.37 6.35 5.57 ***5.40***
136А 1.23.47 ***4.30*** ***4.85*** ***НДСТ*** ***НДСТ*** ***4.77*** ***4.02*** ***НДСТ*** ***НДСТ***

136Д 1.23.47 (45-47) *K06L20I=1 АВАРИЙНОЕ ОТКЛОНЕНИЕ УРОВНЯ В БС
136Д 1.23.47 (45-47) *K06L176=1 ПРЕВЫШЕНИЕ ДАВЛЕНИЯ В БС ПРАВ.
136Д 1.23.47 (45-47) *K06L175=1 ПРЕВЫШЕНИЕ ДАВЛЕНИЯ В БС ЛЕВ.
137А 1.23.48 Gпв1=144 Gпв2=80 Рбс1=75,2 Рбс2=88,2 Нбс11=-369 Нбс12=-300
Нбс21=+157 Нбс22=-51

137Д 1.23.48 (45-47) *K10L045=0 РАЗГРУЗКА ТГ ПРИ АЗ-5
137Д 1.23.48 (45-47) *K10L035=1 СРАБАТЫВАНИЕ БРУ-К1
138Д 1.23.49 (47-49) *K06L005=1 РОСТ ДАВЛЕНИЯ В РП
138Д 1.23.49 (47-49) *K06L034=1 НЕТ НАПРЯЖЕНИЯ 48В 1СШ

Annex 2

Fixation of discrete signals after *DREG* was switched on:

01:39:29 – appeared (maybe not for the first time, because interruption in the work of *Skala* and *DREG* was over 15 min) signals "decrease of level in the *SUZ* emergency tank" and "pressure in *BS* premises over 500 kg/m2"

01:40:01 – appeared sygnal "increased pressure in solid-tight sections (those to the right, closer to *SAOR*) over 500 kg/m2"

01:40:04 – this signal disappered

01:40:24 – signal appeared abain - "increased pressure in solid-tight sections (those to the right, closer to *SAOR*) over 500 kg/m2"

01:40:39 – pressure in *BS*right fell from 40 to 22 atm, pressure of *BS*left was not registered.

01:40:36 – level *BS*left = +750 mm.

01:40:49 – signal disappered - "increased pressure in solid-tight sections (those to the right, closer to *SAOR*) over 500 kg/m2" 01:40:49 – appearde signal – "decrease of pressure in *SUZ* pressure collector"

Annex 3

Fig. 1 Original seismogram, recorded by Norinsk station 26.04.86 г. [1]

In the upper part of the seismogram there is a mark of time when signal "goes into" the probes of seismic station. This time is defined as a sum, i.e. a time of travel of signal from epicenter to seismic station is added to the time of the beginning of the event in epicenter. From this seismogram we can find the time when the event began at epicenter (at ChNPP).
a) The signal "goes into" at 21:24:19 Greenwich time, or 01:24:19 local time.
The signal traveled (see Annex 4) 34 s. Subtraction of "travel" time gives the time when the event at ChNPP began: 01:24:19 – 34 = 01:23:45

So, the probable time of the beginning of seismic event at ChNPP - 01:23:45

Annex 4.

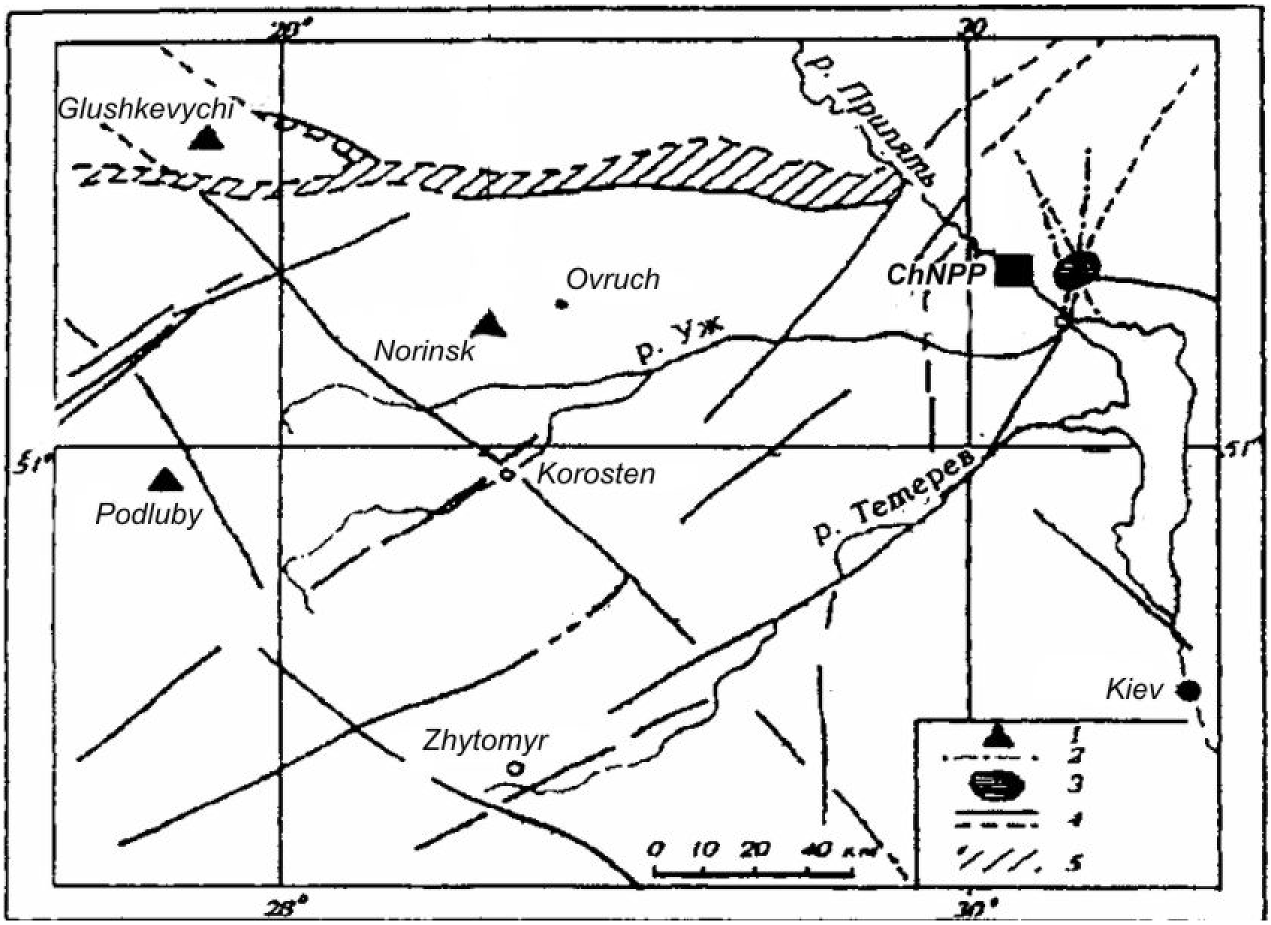


Fig 2. Map of the area [2]:

1 – seismic stations
2 – fixing location of epicenter of the event of 26 April 1986
3 – location of the zone of increased seismic emission
4 – deep faults.

Using the scale, 29 mm = 40 km, and between Norinsk and ChNPP, on the map, 75 mm. Hence the distance traveled by the signal between ChNPP and seismic station

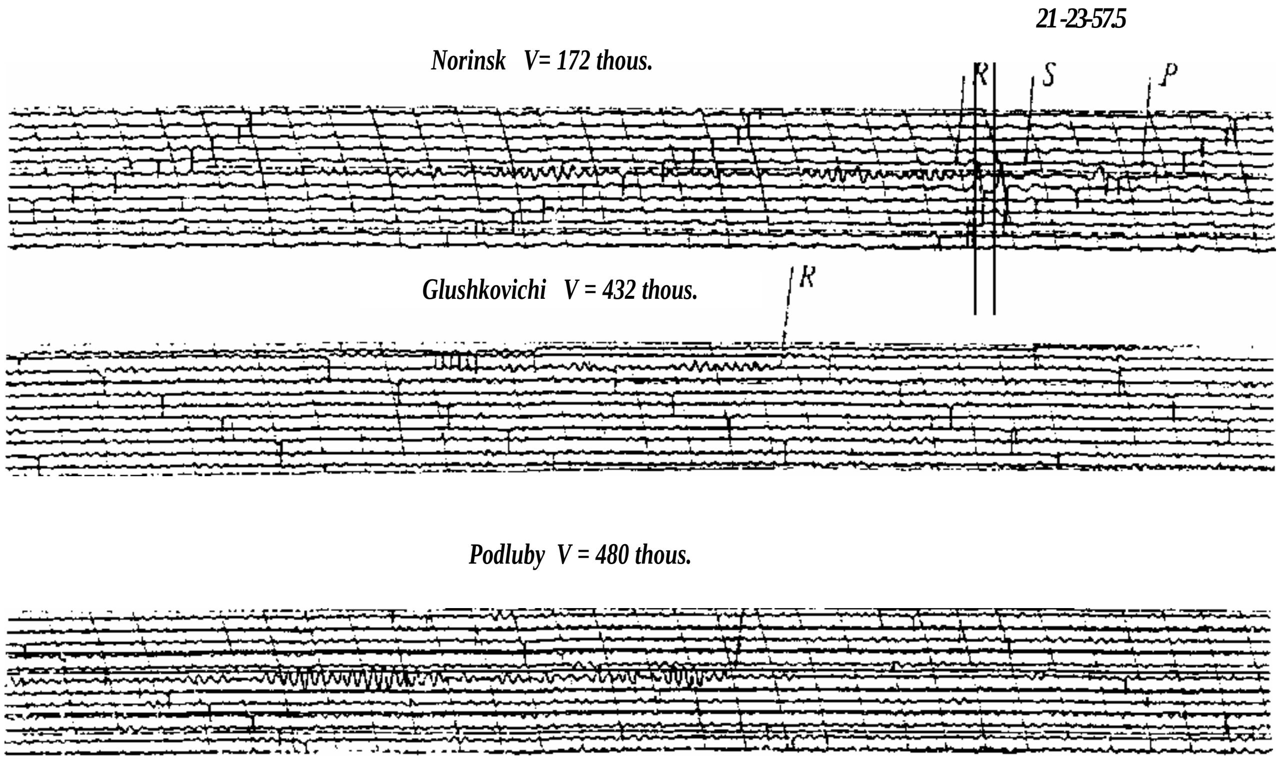
$$S = 73x40 / 29 = 100 \text{ km}.$$

Velocity of signak 2.9 km/s. From here, the time of signal delivery

$$Ts = 100/2.9 = 34 \text{ s}.$$

So, the time of travel of signal from epicenter of the event to seismic station equals 34 seconds.

Annex 5.



1 min

!___________77 mm__________!

Fig. 3. Seismograms of the event of 26 April 1986 (narrowband channels) [3].

The number of maximums on Fig.3 equals two (the first, with a wider base – looks as a double explosion; interval between maximums equals approximately 3.5 mm). Let's calculate how much time elapsed between two peaks:

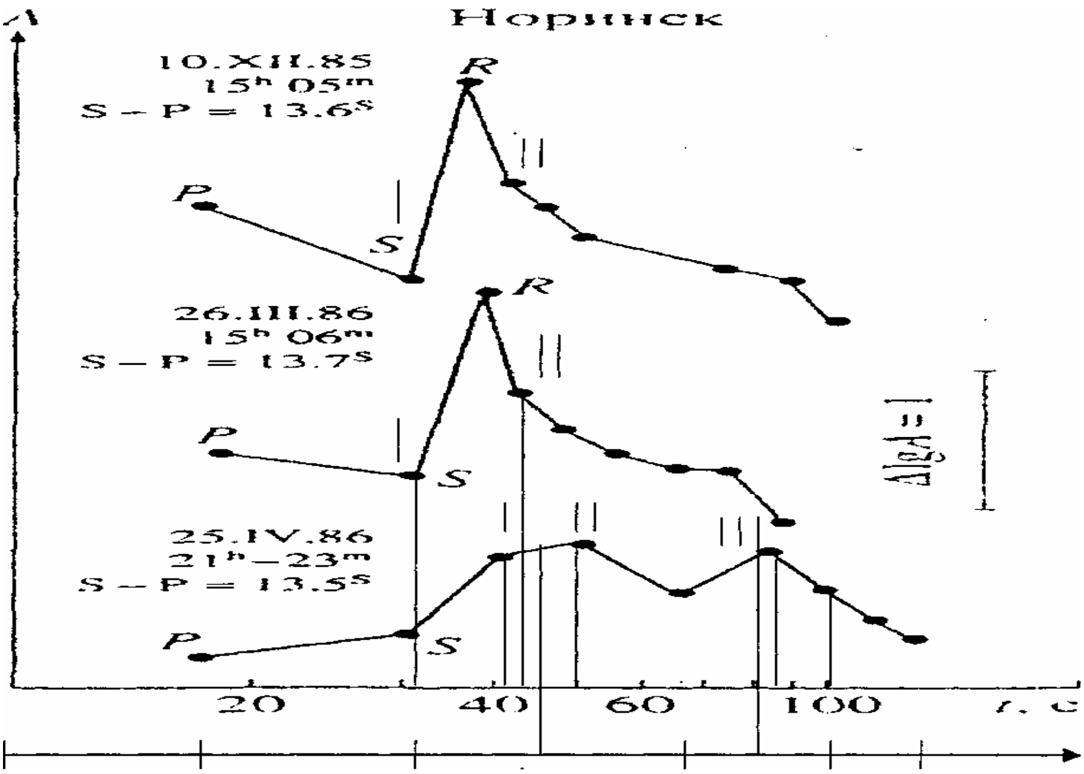
1 min = 77 mm, and between peaks – 3.5 mm. Thus, an interval between two events symbolized by these two peaks

$$T = 3.5\times 60/77 = 2.7 \text{ s},$$

which could be considered as a time between "upper" and "lower" explosions.

So, an interval between explosions could be 2.7 seconds.

Annex 6.



X	a	b	c	d	e	Y	T, seconds
2.8 s	6.6 s	7.5s	9,5s	10.5s	11.4	12.6s	

Fig. 4. Envelope line of two explosions in quarries and the Chernobyl event (Norinsk station). Distance to the source is approximately the same in all cases.

This picture does not agree with the DREG data and explanatory notes of the personnel. It follows from the picture that the duration of seismic event was between 30-40 seconds (distance between peaks II and III, between I and III). And interval between I and II is 10 s, which does not look like a double (prolonged) explosion. If we compare lower fragment with two above, then for the explosions an interval between I and II (one event – explosion, but many dots) is over 10 seconds. It means that between dots we do not see an interval of time between two different events, but some "seismophase" of one event. Chernobyl line (lower) has three such phases – from 30 to 67 s continuous double phase (peaks I and II), and from 67 to 100 s a third phase (peak III). Then the time scale at this picture has nothing in common with the real event in epicenter. This is a time scale for "seismic echo".

But if we compare this picture with seismograms (Annexes 3 and 5) we will see, that the time interval between explosions equals 2.7 s. Due to this we can introduce a new time scale, and on this scale we can mark moments of events at epicenter. Dot b – in the middle of the base of the double (lower) explosion. Dot d – on the peak of the last explosion. Between b and d – about 3 s. Thus we can define the measure of the new time scale, 1 s = 11 mm.

Then we receive that the time interval during which shocks, shakings and explosions occurred, could be of about 10 s (from X to Y).

Continuous (lower) explosion could sound up to 3 s.

(Translated from Russian to English by V. Tykhyy)