Table 2. Suppression of bacterial wilt by the siderophore-minus, siderophore-delayed and siderophore-hyperactive mutants

Strain code	Per cent disease control
Check	
Wild type	
RSI 125	75.00
Sid^{-} mutants	
RSI 1256	25.00
RSI 1258	12.50
Sid^{d} mutants	
RSI 1253	25.00
RSI 1254	50.00
RSI 1257	37.50
Wild type	
RBL 101	12.50
Sid^{++} mutants	
RBL 1011	37.50
RBL 1013	25.00
RBL 1015	75.00

a smaller zone of colouration (Sid^{d}). And, Flu^{-} and Sid^{-} mutants did not inhibit the pathogen *in vitro*.

In the biocontrol experiment, Flu^{-} Sid^{-} (RSI 1256 and 1258) and Flu^{d} Sid^{d} (RSI 1253) mutants failed to control the disease as much as their wild type (Table 2), confirming the role of siderophores in the biocontrol mechanism. The involvement of the fluorescent siderophore (pyoverdin) in the suppression of *Pythium*-induced damping-off of tomato by *Pseudomonas aeruginosa* TNS K2, has been demonstrated using pyoverdine-deficient mutants[9]. The hyperactive mutants (Flu^{++} Sid^{++}) (RBL 1015 and 1011) with higher siderphore production suppressed the wilt disease to a greater extent than the wild type. Similar increase in the biocontrol potential of the fluorescent siderophore over producing mutant MPS 16 M-1 of *Pseudomonas* sp. against *Rhizoctonia solani* in chickpea has been reported[10]. Thus, the study has proved fluorescent siderophore production as a mechanism of biocontrol of the bacterial wilt disease in the fluorescent pseudomonad isolates, RBL 101 and RSI 125.

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A rare earthquake in Antarctica

The Antarctic continent is the largest apparently earthquake-free area on the earth, only a few earthquakes have been located by the Worldwide Standardized Seismograph Network (WWSSN). More than 10 seismological stations have been operating in Anatarctica since the International Geophysical Year (IGY), and the small local tremors recorded by these stations are commonly attributed to calving of the ice shelves or fracturing of the ice sheet. Small earthquakes, probably of volcanic origin, are associated with the active volcanoes at Mount Erebus on the Ross Island and at the Deception Island near the Antarctic Peninsula. The WWSSN detects almost all global earthquakes with magnitude > 4.0. Three such earthquakes have been recorded from Antarctica, one in 1952, another of magnitude 4.9 in 1974, both originating in the northern Victoria Land, close to a major glacier and ice tongue. The third earthquake, in 1985 of magnitude 4.7, was reported to have occurred in Dronning Maud Land. Seismologists suggest that, although the 1974 event had characteristics resembling those earthquakes generated by normal tectonic processes, it is likely to have been caused by movements within the ice. The 1985 event, in contrast, was attributed to normal tectonic processes, and remains the only unquestionable Antarctic earth-tremor[1].

The first seismograph station in Antarctica was operated as early as 1902–1903 at Scott-Base (SBA). Later on, some more stations were operated intermittently by various countries between 1940 and 1952. During IGY, 4 stations were operated, one each at MIR, SBA, WILKES and ADELIE. Two WWSSN stations are in operation from 1963 to 1964 at SBA and SPA. Subsequently, many countries have installed seismographs at their base stations in Antarctica. Due to difficult environmental and operating conditions, many stations have a very high downtime. For this reason, the first hypocentre in the region could be instrumentally located as late as 12 January 1995, when an earthquake of magnitude 4.7 occurred at 82.064°S, 43.993°N and depth of 10 km (ref. 2).

In order to monitor the seismic activity in Antarctica and the Indian Ocean, a reconnaissance survey for site selection and the feasibility of operation of seismological station in Antarctica was initiated during the 16th Indian Antarctic Expedition in January–February 1997. A permanent digital 24-bit seismological station has been installed there during the 17th Indian Antarctic Expedition. The station was fully commissioned on 26 January 1998. The station coordinates are: Lat. 70°45.94′S, Long. 11°44.13′E, elevation 130 m, station code MAIT.

The phase data for Maitri seismic station were communicated to USGS in a particular format for the purpose of global determination of hypocentral parameters.

A special thermally-insulated vault was designed and fabricated by R&D engineers, of Defence Research Devlopement Organization, Pune. A two-metre deep underground pit was dug and the vault was buried inside the pit. An electronically controlled temperature device has been installed in the seismometer vault which maintains the temperature at 17 ± 2°C, while the outside temperature is –25°C. The recording is done in a separate hut, at a distance of 20 ft away from the vault.

The station consists of a three-component short-period seismometer (Teledyne Geotech) with 24-bit digital data acquisition system (Reftek). An internal GPS clock maintained accurate time. Digitization is done at 50 samples/s. A vertical component analogue recorder (S-13, Teledyne Geotech) is also being cooperated and recording is done with ink on RV320B portacorder (Seismic recorder).

Altogether 380 earthquakes have been recorded during the 18th Indian Scientific Expedition to Antarctica, December 1998–March 2000. Most of these earthquakes are teleseismic. Few regional earthquakes were recorded with their epicentres in the ocean. The only nearest local event recorded is shown in Figure 1; the event originated in Antarctica only. Unfortunately the data from the other Antarctic base stations like Russian Antarctica base, Novolazaraveskya, could not be received as those stations were down due to logistic problem. The event being small in magnitude, could not be recorded by WWSSN. The one station data were analysed using SEISAN computer program[3]. The analysis shows that the epicentre of the event lies in Queen Maud Land region with its epicentral parameters as follows:

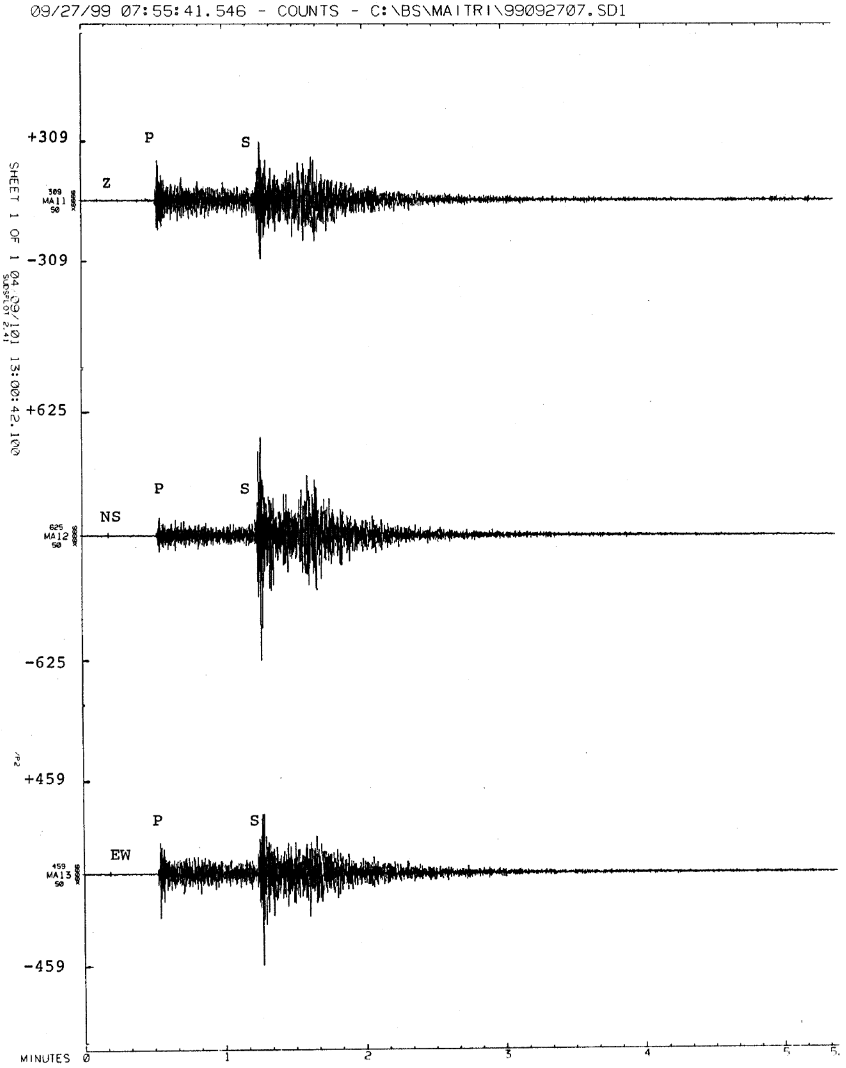

Figure 1. First digitally recorded local earthquake in Antarctica.

Date, 27/09/99; Origin time, 07 : 55 : 17.32 h; lat., 71.049°S; long., 23.335°E; depth, 25 km; epicentral distance, 424 km; azimuth, 99°N; magnitude M_D, 3.4.

The event is probably the first digitally recorded local earthquake in Antarctica.

The source parameters of the above event have been estimated through frequency domain[4]. With the assumption of homogeneous earth model (density $\rho = 2.7$ g/cm^3) and constant P wave velocity ($V_p = 6$ km/s); the source parameters are estimated as follows:

$$\text{Seismic moment} = 4\pi\rho V_P \mu_0/(AS_a), \quad (1)$$

where ρ is density, V_P is the P-wave velocity, Δ is the epicentral distance, μ_0 is the low frequency level, S_a is the surface amplification and A is radiation pattern.

The source radius R is computed by using the formula

$$R = V_S K_P / 2\pi f c_P, \quad (2)$$

where fc_P is the corner frequency of the P-wave and K_P is the related model constant.

The area of the circular rupture plane is

$$A = \pi R^2. \quad (3)$$

The source dislocation D is determined from the expression

$$M_0 = \mu\, DA, \quad (4)$$

$$D = M_0/\mu A. \qquad (5)$$

According to Keilis Borok[5], the stress drop $\Delta\sigma$ is expressed in Pascal with the relationship

$$\Delta\sigma = 7M_0/(16R^3). \qquad (6)$$

Therefore the estimated parameters are

Seismic moment $M_0 = 4.97 \times 10^{15}$ Nm; length of the rupture plane $R = 190$ m; area of the circular rupture plane $A = 1.14 \times 10^5$ m^2; source dislocation $D = 1.339408$ m; stress drop $\Delta\sigma = 31.27$ MPa.

The rupture plane and the source dislocation are estimated using the kinetic rupture model of Brune[6]. The static stress drop $\Delta\sigma$ describes the difference in shear stress on the fault plane before and after the slip.

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Yield estimation of Indian nuclear tests of 1998

We explain below why we consider the arguments put forward by Douglas *et al.*[1], while commenting on the papers by Sikka *et al.*[2–4] and Roy *et al.*[5] regarding yield estimation of Indian nuclear tests of 11 and 13 May 1998, as inappropriate. The data used in their calculations comprise log (*A*/*T*) values of *P*-waves available from some non-Indian stations and Hyderabad station in India, corresponding to Indian explosions of 1974 (POK1) and 11 May 1998 (POK2). Of these, some estimates are made by Douglas *et al.* and the remaining estimates are accepted as such from the NEIC and ISC bulletins. *It may be noted that Douglas et al. have observed that some of the reported values to NEIC and ISC were incorrect.* An independent surface wave magnitude estimate using data from XAN (China, 32.6 deg) and NIL (Pakistan, 6.6 deg) has also been reported by the authors without mentioning any details of the signals and the *relation used* for the *Ms* estimation at NIL, which showed highly attenuated Rayleigh and *Lg* waves. On the other hand, the seismogram of Bhopal, India at a distance similar (6.3 deg) to that of NIL, showed strong surface waves (see figure 2 of Roy *et al.*[5]). One possible reason for the low estimate of Douglas *et al.* is that proper path effects are not taken into account by them for *Ms* estimation. The *Ms* estimate of Douglas *et al.* from the two stations differs from the NEIC reported estimate (four observations) and the estimate made by us (six regional observations). Douglas *et al.* have further reported that the maximum yield of POK2 is ~ 40 kt, whereas this value according to their calculations corresponds to the average value of the yield. *The maximum value of the yield according to the calculations of Douglas et al. is in fact ~ 110 kt.*

The seismic yield of POK2 has been estimated by Sikka *et al.*[2–4] and Roy *et al.*[5] by using close-in, regional and teleseismic data. The scaling of close-in acceleration data gave the combined yield of POK2 around 58 kt (ref. 3). Additional seismic observations of global *P* waves and regional *P* and *Lg* waves gave the estimate of yield in the range of 54–63 kt (refs 4, 5). It may be emphasized here that the potential of seismic *Lg* waves as a stable source-size estimator is now well established[6,7]. Nevertheless, various estimates obtained by Roy *et al.*[5] and Sikka *et al.*[4] from regional *Lg* waves are *conveniently ignored* by Douglas *et al.* The regional surface wave estimate, *Ms* = 3.56, using a calibrated formula for the Indian region, and *not the conventional magnitude scale* as mentioned by Douglas *et al.*, gave the yield in the range of 49–52 kt (refs 4, 5). All these estimates together gave the yield of POK2 in the range of 49–63 kt. The yield of POK2 using radio-chemical methods was estimated as 13 ± 3 kt for fission device[8] and 50 ± 10 kt for the thermonuclear device[9], giving the range of combined yield as 50–76 kt. Further, the ratios of neutron activation products to fission products for the thermonuclear and fission test of 11 May 1998 were also found to be in quantitative agreement with that expected from their radiochemical yields. BARC has also performed simulation studies of the close-in acceleration values and surface features by finite difference and finite element codes (unpublished). These studies also corroborate the estimated yield of POK2. The seismic yield estimates by Sikka *et al.*[2–4] and Roy *et al.*[5] are found to be consistent with the radiochemically estimated yield of POK2. We have carried out various seismic estimations to bring to scientific litera-