4. Field Work and Findings

4.1. Overall mine findings from Phase 2 field work

The mines examined in Cambodia were generally in much worse condition than those found in Jordan or the Falklands, with a substantial proportion being incapable of functioning. In contrast, most of the mines recovered in Jordan and the Falklands appeared to be in remarkably good condition and were clearly capable of operating.

One of the major problems encountered during the study was the difficulty in finding mines of the same type in different locations; this limited the opportunities for ‘like-for-like’ comparisons. The major exception here was the Russian PMN, where samples from Afghanistan were compared to those from Cambodia. The condition of the Afghan mines was significantly better, supporting the intuitive conclusion that—for this mine, at least—a wet climate and highly organic soil promotes faster deterioration.

There was clear evidence from all regions that water was the primary cause of deterioration, but it was surprising how many other contributing factors emerged. In some instances—particularly in Cambodia—mechanical damage and plant action had penetrated the mine casing, enabling water to enter sooner, or in larger quantities than might otherwise have been expected.

In Jordan, many mines were affected by fire, which damaged water-tight seals or created breaks in the casing. For those mines that avoided fire, the hot climate and intense sun in the high minefields of Jordan had done surprisingly little damage to the plastic mine casings. Most metal-cased mines were very well preserved by the Jordan climate, with some Second World War mines still functional.

Among the most resilient plastic-cased mines in the Falklands, the ingress of water was due mainly to ‘human error,’ where detonator plugs had not been tightened sufficiently. In mines that had been properly sealed, hardly any deterioration was evident.

One of the most important conclusions from the field was that the appearance of mines generally reflected their functionality. In other words, mines with noticeable external deterioration were often incapable of functioning, and vice versa.

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17 Brush fires regularly sweep through the dry surface vegetation within mined areas; however, mines buried more than a few centimeters are unlikely to be affected.
18 Particularly the Italian SB-33 and SB-81, which have polycarbonate-based bodies.
4.2. Cambodia mines (see accompanying field images in Annex D)

4.2.1. Russian PMD-6 anti-personnel mine summary of findings

- The wooden case of every PMD-6 had rotted, with only small remnants found. Since the casing forms part of the initiation system (by pushing the retaining pin out to release the striker), these mines could no longer function as designed.
- The MUV-2 fuze components were intact, but were seized and had to be separated using force. The stab receptors were in poor condition and were probably not functional.
- The upper section of the aluminum detonator tube had corroded away, leaving a break of approximately 5-10 mm between the fuze and the main charge. This gap was filled with mud, which would probably have prevented the flash from the stab-receptor from initiating the detonator.
- Burning tests on two charges resulted in eventual detonation, indicating that the primary explosive within the detonator was still viable, and capable of initiating the main TNT charge.

4.2.2. Russian PMD-6 conclusions

- All of the PMD-6 mines examined showed multiple causes of failure, namely:
  - Absence of the casing as part of the initiation mechanism;
  - Seizure of mechanical fuze components;
  - Inactive stab-receptors (subject to confirmation);
  - Interruption of the initiation train.
- The combination of these effects would make it impossible for any of these mines to function as designed. Other PMD-6 mines buried in similar conditions for similar periods are also unlikely to function.
- The TNT charges are still hazardous, particularly since they contain embedded detonators with viable primary explosive. These could be initiated if set alight or subjected to substantial impact.

4.2.3. Russian PMN anti-personnel mine summary of findings

- The steel bands securing the rubber covers were badly rusted in all examples; many were at or near the point of failure. This is known to reduce the detection signature.
- Rubber covers had deteriorated and hardened; some, but not all, were breached. This does not prevent the mine from working, but does allow water into the fuze mechanism.
- The main effect of water inside the mine is to cause the springs to rust. The striker spring is most critical to failure; however, deterioration of the plunger spring could potentially lead to a decrease in operating pressure.
As noted in the previous report, springs in contact with alloy strikers appear to deteriorate more quickly than those around steel strikers.

Most strikers were in operational condition, but one had deteriorated badly and was seized into its channel. This would have caused the initiation mechanism to fail.

TNT charges were in good condition and detonators appeared to be functional. Two detonator tests (using a PMN fuze mechanism in good condition) resulted in detonation.

4.2.4. Russian PMN conclusions

- All of the PMN mines examined in Cambodia showed significant deterioration, but some still appeared to be functional while others clearly were not.
- The most common cause of failure is deterioration of the striker spring, which begins when water enters the mine and eventually results in disintegration. Other likely causes of failure include:
  - Degradation and seizing of the striker;
  - Prevention of operation due to silt build up in cavities.
- Explosive components appear to outlive the fuze mechanism.
- These findings are consistent with those from the first phase of the study.

4.2.5. Russian PMN-2 anti-personnel mine summary of findings

- The rubber pressure plate covers were badly perished, with large sections missing. In several examples, the top edge of the plastic casing was also split. This damage would not prevent the mine from working, but does allow water and silt into the fuze mechanism.
- The main effect of water inside the mine is to cause the springs to rust. The striker spring and detonator slider spring are both critical to operation and their deterioration can cause failure.
- Deterioration of the plunger springs could potentially lead to a decrease in operating pressure, but appears to be offset by seizing of the plunger itself.
- In every PMN-2 examined, the striker was seized into its channel; this appears to be caused by a build-up of corrosion, leading to expansion beneath the metallic plating.\(^\text{19}\)
- In several examples, the mild steel firing pin (which is inset into the end of the striker) had rusted away completely, leaving the striker with a flat end.
- In all examples, the explosive charges (RDX/TNT) and boosters were in good condition and detonators appeared to be functional. However, the detonator is held out of line until the mine is actuated, and relies on the slider spring to bring it into line.

\(^\text{19}\) Some PMN-2 mines examined for a separate study have stainless steel strikers, which may be more resilient.
4.2.6. **Russian PMN-2 conclusions**

- All of the PMN-2 mines examined showed significant deterioration and none appeared to be capable of functioning.
- The most common cause of failure is seizing of the striker into its channel. However, some mines showed multiple points of failure, including:
  - Absence of the firing pin;
  - Seizure of the detonator slider and spring;
  - Seizure of the plunger.
- Explosive components appear to be stable and functional.
- These findings are consistent with those from the first phase of the study.

4.2.7. **Chinese Type 72 anti-personnel mine summary of findings**

- The rubber pressure plate cover was badly perished or absent in all of the mines examined. In every case, this had allowed water and soil to penetrate the mine body.
- Without the smooth green rubber cover, the appearance of aged Type 72 mines is quite different, and may not be recognizable to people who have only seen it in new condition.
- The primary effect of water inside the mine is to rust the mild steel firing pin. Initially, this causes the tip to become rounded and therefore shorter, which makes it far less likely to fire the igniter.
- The likelihood of initiation continues to fall as the mass of steel within the firing pin decreases further. This, combined with rusting of the helical arming spring, may also make the mine difficult or impossible to locate using a metal detector.
- Most of the Type 72 mines examined had fuzes that were already actuated (shown primarily by the inversion of the Belleville spring), but the mines had not detonated.
- Most explosive components remained in reasonable condition and appeared to be functional. However, some of the stab-sensitive igniters were no longer operational.

4.2.8. **Chinese Type 72 conclusions**

- Breaching of the thin rubber cover means that all Type 72s examined had significant levels of deterioration. However, some still appeared to be capable of functioning.
- The most common cause of failure is rusting of the firing pin. Degradation of the igniter may also cause failure, particularly in conjunction with a short, rounded firing pin.
- With the rubber cover missing, the mine can be difficult to recognize; this has important implications for mine risk education and deminer training.
● Older mines with minimal metallic content may require alternative means of detection.
● A complete explosive train (detonator, booster and main charge) may remain even when the fuze is non-functional. This means the mine is still hazardous.
● These findings are consistent with those from the first phase of the study.

4.3. Jordan mines (see accompanying field images in Annex E)

4.3.1. US M14 anti-personnel mine summary of findings

● After long-term exposure to hot conditions and bright sunlight, the M14 plastic casings showed few signs of deterioration, although the color had faded in some places.
● The stab-sensitive detonators and main explosive charges appeared to be in good condition and functional, with only slight superficial degradation.
● The material used for the Belleville spring appears to be highly resistant to deterioration.
● The mild steel firing pins had rusted to varying degrees, though most of the corrosion appeared to be superficial and unlikely to affect performance.

4.3.2. US M14 conclusions

● The bonded casing and rubber seals have permitted very little water to enter these mines. The Belleville spring, detonator and main charge have also proved resilient.
● The firing pin is probably the most vulnerable component, yet even these were relatively unaffected.
● The mines examined were probably capable of functioning as intended and, given the slow rate of deterioration, could be expected to remain so for many more years.

4.3.3. US M15 anti-personnel mine summary of findings

● The M15 mines were in good condition externally, with only superficial rust.
● Rust was confined mainly to the side of the mine, but had not penetrated the casing. Very little rust was visible on the top surface or base, other than the wire carrying handle.
● The steel fuze cap could not be unscrewed from the central well of the pressure plate using the available resources. Although little corrosion was visible, both assemblies are steel and had rusted together enough to prevent movement.
4.3.4. **US M15 conclusions**

- Examination of the internal components could not be conducted; however, based on the external condition, it is highly likely that the fuzes were in good condition and that the mines were fully functional.
- There is no evidence that water had penetrated the casings of these mines. Based on the rate of degradation seen here, these mines could remain intact for many more years.

4.3.4. **US M19 anti-tank mine summary of findings**

- The M19 mines casings were in excellent condition, with no visible deterioration.
- Rubber seals between the fuze assembly and body had hardened, but there was no indication that water had penetrated the mines.
- All explosive components appeared to be in good condition and fully functional.
- The main Belleville spring, responsible for maintaining an adequate operating pressure, showed no sign of deterioration. The small firing Belleville spring was also unaffected.
- The firing pin in the M19 is stainless steel and therefore highly resistant to corrosion.

4.3.6. **US M19 conclusions**

- The fiberglass used in the M19 casing appears to be virtually unaffected by age.
- Rubber seals are likely to fail gradually over coming years.
- The fuze assembly and detonator are both well protected and resilient.
- Water entering the mine body may take a long time to have any significant effect.
- M19 mines are likely to remain functional for many years to come.

4.3.7. **Belgian M35 anti-personnel mine summary of findings**

- Of the four M35 mines examined, three appeared to be functional.
- The mine (No. 1) that showed the greatest deterioration was protruding from the ground.
- Mine No. 1 had a distorted casing and a damaged fuze which had permitted the ingress of water. Bulged M35 mines are also seen in parts of Africa.
- Despite being misshapen, all of the plastic casings maintained their integrity.
- The explosive charges were crumbly, but it is not known whether this would affect performance.
- Most detonator and igniter capsules showed surface degradation, but appeared functional.
The spring striker wires were functional in most mines. Both wires in mine No.1 were heavily corroded due to the ingress of water; this would have caused the fuze to fail.

4.3.8. **Belgian M35 conclusions**

- Buried M35 mines could remain functional for many years to come.
- Mines on or near the surface may be damaged by brush fires in Jordan.
- Once water has penetrated the casing, the most likely failure mechanism is the deterioration of striker wires, detonator and igniters.

4.3.9. **British Mk 2 anti-personnel mine summary of findings**

- The fly-off lever was heavily rusted, posing a potential danger that, with little stimulus, it might release the striker and detonate the mine.
- Mk 2 mines are therefore considered too unpredictable to examine in detail, however:
  - Trip wires were absent, so the mines could not function as designed.
  - All visible external steel components were heavily rusted.
  - The condition of strikers and springs could not be established but, based on findings from the Mk 5 mines, might still be functional.

4.3.10. **British Mk 2 conclusions**

- Although incapable of functioning as intended by tripwire actuation, these mines may still pose a significant threat if disturbed.
- The most likely failure mechanism is that the strikers, springs and retainers seize together to prevent operation of the fuzing mechanism.

4.3.11. **British Mk 5 anti-tank mine summary of findings**

- The external steel surfaces were rusted, but not excessively.
- The alloy fuze body showed only slight deterioration.
- The simple fuze mechanism (spring-loaded striker retained by a shear pin) was functional.
- The booster charge was dry and in perfect condition, suggesting that the detonator assembly was probably in a similar condition.
- The main explosive charge appeared to have melted and recrystallized, resulting in expansion.
- Expansion of the main charge had created a friable mass and forced the base plate off the mine.
4.3.12.  **British Mk 5 conclusions**

- Unlike many other mines showing the effects of aging, the Mk 5s appeared to have fully functional fuzes.
- It is unlikely that the main charges would be capable of sustaining complete detonation.

4.4.  **Falkland Islands mines (see accompanying field images in Annex F)**

4.4.1.  **Spanish P4B anti-personnel mine summary of findings**

- Most of the P4B mines examined appeared to be fully functional.
- Deterioration of the plastic casings has begun, but—in most instances—is progressing at a far slower rate than expected. Most mines have retained their structural integrity.
- The ingress of water into the fuze assembly has caused only minor deterioration of the striker springs. This will not significantly affect the detection signature or the mine’s ability to function.
- The ingress of water into the detonator assembly may render the mine inoperative; this would need to be confirmed by testing.
- The lead foil was present in all but one of the mines examined. The manner in which the foil splits (when the fuze assembly is fitted) may affect the detection characteristics of the mine. Determining this would require additional trials.
- The TNT HE content is stable and well preserved.

4.4.2.  **Spanish P4B conclusions**

- The plastic used in the P4B casing has proven more resilient than expected.
- The mines are best preserved when buried, since the plastic becomes brittle when exposed to sunlight.
- The P4B fuze may be capable of functioning even if the fuze spring has rusted away.
- The detonator is prone to becoming wet, and this is likely to be the primary failure mechanism in the long term.

4.4.3.  **Italian SB-33 anti-personnel mine summary of findings**

- Most of the SB-33 mines examined appeared to be fully functional.
- The rubber pressure plates were distorted where the material appeared to have softened; this probably indicates the beginning of degradation that would eventually lead to failure.
- Deterioration of the rigid mine casings was minimal and all of the mines examined retained their structural integrity.
• Minor dampness inside the mines has caused only minor deterioration of the striker springs. This will not significantly affect the detection signature or the mine’s ability to function.
• Degradation of the detonator assembly, due to dampness, may render the mine inoperative; this would need to be confirmed by testing.
• The HE charges are well preserved, despite some being cracked.
• Where water had penetrated a mine, the striker spring and detonator capsule showed substantial deterioration; this would almost certainly have prevented it from functioning. In the long term, this is what could be expected to happen to all SB-33 mines in the Falklands.

4.4.4. Italian SB-33 conclusions

• The SB-33 is extremely resistant to wet conditions.
• The weakest points are the rubber cover section of the casing and the O-ring sealing the detonator plug.
• Once water has penetrated, both the detonator and the fuze spring are vulnerable.
• The rubber cover of the SB-33 may prove vulnerable to hot, dry and bright conditions.

4.4.5. Italian SB-81 anti-tank mine summary of findings

• Most of the SB-81 mines examined appeared to be fully functional.
• The mine casings showed no signs of deterioration; however, prolonged exposure to sunlight is likely to cause degradation that would eventually lead to failure.
• Minor dampness inside the mines has caused only superficial rusting of the striker springs. This will not significantly affect the detection signature or the mine’s ability to function.
• Degradation of the detonator assembly, due to dampness, had occurred in some mines and might render the mine inoperative; this would need to be confirmed by testing.
• The HE main charges and boosters were in good condition.

4.4.6. Italian SB-81 Conclusions

• Like the SB-33, the SB-81 is extremely resistant to wet conditions.
• Once water has penetrated, both the detonator and the fuze spring are vulnerable.
• The pressure plate is likely to be vulnerable to hot, dry and bright condition.\(^{20}\)

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\(^{20}\) Other Italian mines with similar structures (such as the TC/6, VS-1.6 and VS-2.2) tend to fail in hot climates when the pressure plate hardens and cracks develop in the thin shoulder. This prevents the pneumatic fuzing system from working.